OPEN SYSTEMS IN PRACTICE AND THEORY: THE SOCIAL CONSTRUCTION OF PARTICIPATORY INFORMATION NETWORKS

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OPEN SYSTEMS IN PRACTICE AND THEORY:
THE SOCIAL CONSTRUCTION OF
PARTICIPATORY INFORMATION NETWORKS

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Over the last several years there has been a dramatic shift in the role of amateurs, volunteers and hobbyists as it pertains to the production, distribution and use of information and communication technologies. The work presents four case studies that explore this transition and aim to explain how and why large-scale, participatory systems that are open to volunteer contribution are becoming important in our time. The cases include: (1) Linux, a free computer operating system, that is disrupting proprietary software models (2) BiOS, an initiative that aims to import participatory models into the life sciences; (3) the American Radio Relay League, a volunteer organization that connects radio hams in order to relay messages from coast to coast; and (4) the Ground Observer Corps, a cold-war paramilitary organization that uses volunteers as human radars for detecting enemy aircraft. The dissertation explores continuities and discontinuities between these systems and traditional information networks, develops the analytic term 'open systems', and builds an explanatory framework that shows how relevant social groups who negotiate laws, norms, markets, and technical architectures, or code, effect the social construction of these systems. The work uses this framework to explore the clashes between the ideologies of openness and enclosure.

BIOGRAPHICAL SKETCH

Shay David was born in Israel, and grew up in Israel and California, alternately. He is interested in the complex interconnections that exist among technology and ideology, language and legitimation, authority and assimilation, expertise and reputation. Shay holds a B.Sc. in Computer Science and a B.A. in Philosophy, Magna Cum Laude, from Tel-Aviv University, and an M.A. from New York University where his interdisciplinary research thesis focused on the political economy of free and open source software and file sharing networks. Shay is also a fellow at The Information Society Project at the Yale Law School, where he contributes to policy making in the area of Access to Knowledge.

Shay is an entrepreneur who co-founded two software start-up companies, and was involved for several years in software research, design, and development, combining open source and proprietary software. He shares his time between Ithaca, New Haven and New York City, where his wife Ofri, who is an exhibiting video artist, is working on several large-scale art projects.

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As the poem goes, when I set out on my journey to Ithaca, I prayed that the road is long, full of adventure, and full of knowledge. I realized along the way that the journey towards a PhD was also a surefire route to accumulation of great personal and intellectual debt. Indeed my lenders are many and I hope to be able to repay them one day; I want to start by acknowledging the many people without whom my work would not have been possible.

My interest in ‘open systems’ started while I was still at NYU working with Riaz Khan and Stefan Helmreich as I was writing my MA thesis on the political economy of free software. Both Riaz and Stefan provided invaluable lessons as I was making my first steps in primary research. Several years later, NYU proved a fertile ground for a less formal study/support group in which Biella Coleman, Joseph Reagle, Samir Chopra, Jelena Karanovic, and myself would get together to rant about life as ABDs and exchange ideas about Open Source, Open Systems, Free Software, and other such delights. This groups’ feedback on early drafts of my work, from the outline to the chapters, as well as the generous sharing of their own ideas, has provided me with a wonderful opportunity to expand my work. Also at NYU, I’ve benefited tremendously both as a speaker and a participant in Helen Nissenbaum’s ITS Colloquium series. This forum provided yet another occasion for exchanging ideas about how information technology and society interact, and Helen’s comments on several of my earlier works was instrumental to the development of my ideas about accountability in open systems. At the same round-table I have also met Gaia Bernstein, who have since become an esteemed colleague and also a great friend with whom I often discuss the complex set of issues that intersect S&TS and legal scholarship.

When I first came to Cornell I was lucky enough to be part of what must be the best cohort ever to set foot in Ithaca. Alan Dafoe, Lisa Onaga, Joseph 'Jofish' Kaye, and Janet Vertesi were not only my partners in crime at the 'Dinner Club of 2008' which provided solace from the travails of student life, but also true friends without whom Ithaca could never be the same (Swedish Saunas in snowy February nights notwithstanding.) My gratitude extends to the rest of the Cornell community as well, including both the S&TS department and the Information Science program. In both of these communities I have always found intellectual stimulus in talks, lectures, conferences, and events, as well as bighearted friendship. I owe special gratitude to Anat Nidar-Levi and Rosemary Adessa over at 301 College Avenue, and Stacy Sullivan, Judy Yonkin, and Debbie Van Galder at Rockefeller, for providing me endless and generous administrative support. The many rides between New York City and Ithaca that I shared with Josh Greenberg, were an occasion for long ruminations about S&TS, and the beginning of a great friendship. Adelheid Voskuhl and Nab Sharif were also inspirational for me.

When the time came to do my fieldwork, I was supported by a National Science Foundation dissertation completion grant (award number SES-0551426), and I am thankful to the NSF, John Perhoni, the program officer, and anonymous reviewers for their trust in me. Many other people helped me get the fieldwork done. Tab Lewis and Ken Schlessinger at the National Archives at College Park went way beyond the call of duty in helping me gather material for my case study on the Ground Observer Corps, and so did David J. Haight, at the Dwight D. Eisenhower Presidential Library. Perry Williams, W1UED, an avid ham and the American Radio Relay League's chief archivist, was an invaluable source for my case on the ARRL. I owe special debt to Richard Poynder, who shares many of my research interests and interviewed many of my interviewees, for making his sources available to me. My longtime friend Assaf Distelfeld was a wonderful teacher during a crash-course in molecular biology.

Of course, I could not have completed this project without the willing support of my many interviewees. All of them inspire me in their endless dedication to their cause, more often than not as volunteers. Of this group two individuals stand out. Richard Stallman, the originator of free software, who is both a lead programmer and a community builder, and Richard Jefferson, who has spent the last two decades bringing the open methods to agricultural innovation. Both Richards have been generous to me and forthcoming in sharing their wisdom and knowledge and were always tolerant to my sometimes-penetrating questions.

Throughout my project I have been working with four of the most supporting and caring faculty members Cornell could offer. As my mentors and committee members, Trevor Pinch, Ron Kline, Geri Gay, and particularly my adviser, Phoebe Sengers, provided guidance, discipline, and feedback, without which my project could not have come to fruition. I took inspiration from their diverse research and writing and have always found pleasure in our many one-on-one and group interactions. Each of them shaped my project in different ways, and the sum of their influence allows my research to be as interdisciplinary as it is, and for that I am grateful. Other faculty at Cornell, including Carl Lagoze, Jeff Hancock, Michael Lynch, and Bruce Lewenstein, gave me valuable feedback and useful comments on some of my earlier work. Tarleton Gillespie was a valued mentor throughout my project, and his detailed comments, large and small, on various aspects of my work were always useful and thought provoking.

Three years ago, my good friend Shlomit Wagman invited me to give a guest lecture over lunch at the Yale Law School Information Society Project. This fateful invitation became an intellectual adventure as I became a fellow of the ISP and moved to Yale. At the Yale Law School, Both Yochai Benkler and Jack Balkin, in their writing and during our personal interactions, have helped me re-discover normatively and shape my ideas. I was fortunate to share an office with Eddan Katz who stewarded the ISP in a period of dizzying activities and rapid growth while always finding the time and attention of a close friend. Amy Kapczynski, Katherine McDaniel, Shyam Balganesh, Hong Xue, David Tannenbaum, Lea Shaver, Laura DeNardis, Laura Forlano, Michael Zimmer, James Grimmelmann, and Mike Godwin as well as Pascale Mathieu and the rest of the ISP family provided role models for passionate academic pursuits that are committed to real-world change. Together I hope we made a difference for the future of Access-to-Knowledge.

In many ways this work is a result of my parents commitment to excellence. From an early age they encouraged me to be curious and inquisitive, to pay attention to my environment, ask hard questions, and follow my interests, wherever they led. They have always supported my three younger brothers and myself in the most generous and accommodating way possible, giving us a launch pad to our future. From them I learned that people who say something cannot be done better move out of the way of the people who are doing it. I will forever be indebted to my parents for the loving, caring, and supporting family that they have shaped and for always being there for me.

Finally, more than anyone else, I want to thank my wife Ofri, my soul mate for over a decade. Without her support I could not have started this project, let alone finish it. Ofri had always given me free rein to pursue my interests just as she had given me emotional backing and loving companionship. Without Ofri and her free spirit, her creativity, and her inspiring commitment to one's art, I would have never had the guts to embark on such a long journey. For the trust and thrust she had given me, I shall remain eternally obliged.

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CHAPTER 1:

TOWARDS A THEORY OF 'OPEN' SYSTEMS

This dissertation starts with an observation and three questions. The observation is that over the last several years there has been a dramatic shift in the role of amateurs, volunteers and hobbyists as it pertains to the production, distribution and use of information and communication technologies. The questions are (1) what happens to social structure, economic logic, and regulatory regimes, when large groups of volunteers come together to build information technology? (2) What does the blurring of lines between amateurism and professionalism, on a grand scale, mean for S&TS and its understanding of the ways in which technology develops and stabilizes? And (3) what does this shift entail for society?

Throughout the twentieth century, amateurs, hobbyists and volunteers had important roles in challenging governments and profit-seeking firms.[1] For the most part, however, they had either been on the fringes of innovation pertaining to information and communication technology (ICT) or have been subsumed within the market economy. Today in contrast, groups of volunteers and amateurs come to the center of the ICT arena, offering alternative sources for knowledge and tools while using models of innovation that aim to eclipse traditional models. More than anywhere else, this transition is apparent in the software sector, which, during the last two decades, became the locus of a struggle between those who promote proprietary software and those who favor Free and Open Source Software (FOSS).

[1] Haring finds that "hobbyists demonstrated diverse options for technical culture when they engaged with technology [while] their methods and values were independent from, and at times in direct conflict with, the technical culture of profit-driven production." See Kristen Haring, *Ham Radio's Technical Culture*, *Inside Technology* (Cambridge, MA: MIT Press, 2006), 17.

Since the 1950s software was produced by either government-sponsored academic centers or by profit-seeking firms. Over time, a private sector for software emerged and a proprietary model for software development stabilized as the primary mechanism for the production of software. This proprietary model is based on tight control over the software's source code, a practice that underwrites the ability to sell software in the marketplace. The FOSS movement challenges this model and offers an alternative that is disruptive to the software industry. Unlike proprietary software, FOSS is produced by loosely coordinated, geographically distributed groups of programmers, who distribute the software and its source code for a very low fee --or even for free-- while encouraging future modifications. Evidently, since the late 1990s, FOSS has proliferated and today there is hardly any aspect of the software sector --from servers to desktops, from scientific applications to gaming-- which had not been effected by FOSS. According to FOSS advocates, FOSS now accounts for more than 50% of the global programming effort.[2] Moreover, recent statistics show that the Internet highly depends on FOSS, with over 70% of all Internet traffic delivered using FOSS servers.[3]

With FOSS making such big waves in software, the 'open source' model, which is based on principles of large-scale participation, collaboration, cooperation, coordination, and sharing, is now being adopted in other fields of ICT too. In some cases these models are used with direct reference to the FOSS movement whereas in other cases FOSS serves only as inspiration. Evidently, open source systems are mushrooming in various domains that span a whole gamut from new models for the creative and distributed production and exchange of music and news, through a shake-

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[2] Eben Moglen, "The Iphone and the Empire" (paper presented at the Information Law Institute / ITS Speaker Series, New York University, March 19th, 2007).
[3] For a comprehensive review of recent market statistics, see David A. Wheeler, *Why Open Source Software / Free Software (Oss/Fs, Floss, or Foss)? Look at the Numbers!* [Web] (November 14th 2005 [cited February 2nd 2007]); available from http://www.dwheeler.com/oss_fs_why.html.

down of scholarly communication chains, the revitalization of dictionaries and encyclopedias, as well as new modes of research in the natural and life sciences.

At the heart of the transition from ‘closed source’ to ‘open source’ systems are actors that challenge accepted notions about what ICTs are, and how they should be designed, produced, distributed and used. On the face of it, the actors that try to ‘free’ or ‘open up’ ICTs do so by espousing mechanisms for large-scale, networked, participatory, collaboration, which pose an alternative to hierarchical firms and price-based markets. Seemingly, these novel systems rely on the work of diversely motivated volunteers that cooperate in community-like social structures in order to produce information technologies and knowledge embedded goods in a highly participatory processes, without relying on pricing signals or firm-like hierarchies and without conceiving of knowledge as property. A second look, however, reveals a more complicated picture. As much as these systems shy away from hierarchy and from the working principles of closed, centrally controlled systems, they also rely on many aspects of closed systems, and historically they are co-developed together with closed systems in a symbiosis that is not yet well understood.

Digging yet deeper, things get even more complicated. An ‘open source’ vision of the information economy threatens some of the world’s largest corporations; incumbents in the ICT industry view their fields of operation as a fertile ground for profit-driven businesses. For all they care, these organizations wish to maintain an industrial-like order for the information economy-- with themselves in the center. With its alternative interpretation of knowledge, information, and property, FOSS aims to turn over the ground under their feet. Two things happen as a result: (1) cynically perhaps, the new ‘open’, participatory, volunteer-based models are being appropriated and co-opted by existing powers that find in the open source model easy access to cheap labor; and (2) the battle soon transcends from the technological sphere to the legal system where Intellectual Property Rights (IPR) such as patents, copyrights, trademarks and other legal tools become the primary means for control. Combined with the fact that for a variety of other reasons, in the last few years, IPR protections have reached historical heights internationally, the stakes are upped. Consequently, as more and more aspects of modern society are mediated by ICTs, the outcomes of this clash will have a growing influence on our lives. The transition from a political economy and socio-technical order in which the key actors that control ICT are governments and firms to a participatory model in which the main actors are self-selected volunteers, can greatly alter the ways in which people communicate with each other, engage in business, study, participate in their culture, eat, create and even procreate.

The primary objective of this dissertation is to explain this conflict and evaluate its implications. How did this transition come about historically? What are some of the commonalities and differences among these systems and what are their organizing principles? Who participates in them and why? In what ways do they depart from earlier systems, and in what ways do they rely on them? How do they aim to change their sectors, and why? And, as problematic as these terms may be, what does all this mean for the future of the 'information society', taken here to mean Western society in an age in which large parts of the economy revolve around information?[4]

In an attempt to answer these and other questions, the chapters that follow will scrutinize, evaluate and explain four technological systems that have developed within

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[4] A detailed analysis of the different meaning of this term are beyond the scope of my work, and have been discussed elsewhere. See Frank Webster, *Theories of the Information Society*, 3rd ed., *International Library of Scoiology* (New York: Routledge, 2006). See also Manuel Castells, *The Rise of the Network Society* (Cambridge, MA ; Oxford: Blackwell Publishers, 1996). For my purposes here, the term information society would mean the Western society in which the case studies take place as it pertains to the central role that information plays in it.

four very different historical contexts. The work will focus on two contemporary case studies: (1) Linux, a free computer operating system, which is the largest and most famous FOSS project; and (2) BiOS, an initiative that aims to import the open source methodology into the life sciences. Both case studies are based on comprehensive fieldwork, which I conducted over the last five years that included archival work, interviews, participation, and participant-observation. Both BIOS and Linux were born at a pregnant historical moment at the end of the twentieth century when the stabilization of cheap networking and communication technologies and the rise of the Internet underwrote the shift from what Yochai Benkler calls 'an industrial information economy' to a networked one.[5] Clearly, though, principles of volunteerism and cooperation were practiced many years before the Internet, and both Linux and BIOS take inspiration from much older systems. To explore these historical precedents and to add a historical perspective to my arguments, the dissertation will review two additional case studies: (3) the American Radio Relay League (ARRL), a volunteer organization which operated in the United States at the turn of the twentieth century, connecting radio hams in order to relay messages from coast to coast; and (4) the Ground Observer Corps, a cold-war paramilitary organization that was operated by the U.S. Air Force during the 1950s employing volunteers as human radars in order to detect enemy aircraft. Both of these historical cases present similarities to and differences from the contemporary cases that will prove illuminating.

Through the historical cases I will demonstrate that large-scale collaboration among thousands of volunteers in creating ICTs is not a new phenomenon. There is also nothing new about amateurs and hobbyists who aim to eclipse the achievements of professionals. In contrast to recent scholarly and popular works that see the current

[5] Yochai Benkler, *The Wealth of Networks : How Social Production Transforms Markets and Freedom* (New Haven, CT: Yale University Press, 2006), 29-35.

battle between ‘closed’ and ‘open’ models as something unique to the beginning of the twenty first century, I will argue that the recent systems are manifestations of a struggle between openness and enclosure that is typical to participatory information networks. What is different in this era is the ease and low cost with which such large-scale collaboration can be practiced and the blurring of the lines between amateurism and professionalism that is enabled when massive participation is afforded by networks like the Internet.

It is important to stress that the four cases I selected do not offer direct causal relations. Unless where I specifically specify this in the body of the text, the earlier cases did not induce the later ones and for the most part actors of the contemporary systems I study below are oblivious to the historical precedents. By juxtaposing cases from different historical periods I do not suggest that history is moving in a particular direction, or that somehow the earlier cases bring about the later ones. I’ve selected these historically diverse cases in order to investigate the conditions under which large-scale participatory networks that are open to volunteer participation emerge and thrive.

Along the same lines, it is also important to stress that the explanation I offer to these systems is not a universal theory that can explain technological systems in general, but rather a focused approach that can illuminate and help us to better understand a certain class of systems that revolve around information networks in the twentieth and twenty first centuries, systems which hold great promise as well as potential perils. To do so, the work aims to identify and critically analyze the potential continuities and discontinuities between ‘closed’ and ‘open’ systems, document discontinuities where they exist, explain how these discontinuities came about (focusing on the last two decades of the twentieth century,) assess their future potential, and inform the process of their stabilization. Along these lines, the dissertation will focus on three themes.

1. First, this dissertation will contribute to the S&TS literature by telling stories that have been largely overlooked in S&TS before, and by outlining potential explanations to them. Through the case studies I will show how large groups of volunteers solve problems pertaining to collaboration, cooperation, coordination, sharing, distribution and participation. The work will investigate who participates in these systems and why, the typical structure of communities that are open to volunteer participation, the ways in which these communities self-regulate, and the economic logic that drives them. As I will show in the cases of more than 800,000 volunteers that are trying to detect Soviet bombers by visually searching the sky, a network of thousands of radio amateurs engaged in free relaying of messages across the continental United States, a group of hackers producing a free operating system, and a community of scientists collaborating on perfecting non-proprietary gene transfer technologies, despite apparent differences among them, these systems have many commonalities that are useful when trying to explain the continuities and discontinuities between these systems and older ones.
2. Second, I will develop the analytic concept of 'open systems'[6] in order to explain the tensions between the 'open' and 'closed' models. Throughout this work the term 'open systems' shall be used as shorthand to describe the class of systems that are open to volunteer participation and that, as a result, exhibit certain commonalities or, to borrow from Wittgenstein, 'family resemblances.' The

[6] Much of this work will be devoted to explicating the concept of 'open systems'. In those explanations I rely on the general notion of 'technological systems' as it is developed in Bijker et al., whereby technological systems represent a seamless web of social, technical, political, environmental, and economic factors that include artifacts, people, institutions, ideas, methods, etc., which present themselves to system-builders as interconnected constraints on the problems that need to be solved. See the discussion on theoretical foundations in Chapter 2, and the discussion of 'open systems' as an ideal type in Chapter 7.

systems described here as 'open' overcome challenges of participation, collaboration, coordination, cooperation, sharing, and distribution in many similar ways. They can be defined as distributed systems that afford an accessible and flexible type of collaboration whose results may be widely shared.[7] Arguably, these commonalities warrant the amalgamation of very different phenomena into one set but they do not imply that 'open systems' exist in the world without an analytical eye to observe them. The term 'open systems', in this shorthand notation, simply refers to those twentieth century ICT systems in which a group of volunteers comes together to build an information network.[8]

3. The third theme starts exploring the larger effect that 'open systems' may have on democracy and 'democratic culture', a term that I will define in Chapter 2. I will explore this question through an analysis of the modes of participation in open systems, investigating the 'architectures of participation' and how these relate to notions of access to knowledge, community, and democracy. Due to limitations of scope and focus, my exploration of this theme in this work is cursory, outlining the main issues without going into much depth. I mainly intend this exploration to mark directions for future work, and potential connections to other bodies of literature that are beyond the scope of this work.

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[7] In Chapter 7, I expand the terminology proposed by Joseph Reagle. See Joseph Reagle, "Notions of Openness" (paper presented at the FM10 Openness: Code, Science and Content, Chicago, 13-15 May 2006).

[8] In my explanation, I borrow an idea from Daniel Bell. Bell argued that post-industrial society would not displace the industrial society but rather overlay it in profound ways, much as industrialization continues to coexist with the agrarian sectors of our society. In the same way I hope to show that open systems overlay the field of ICTs with new possibilities. See Daniel Bell, *The Coming of Post-Industrial Society; a Venture in Social Forecasting*, 2nd ed. (New York, NY: Basic Books, 1976; reprint, 1976), 118.

Departing from the closed world

My work starts with the premise that what unites many technologies—from the plow to the personal computer, from the steam engine to the search engine, from the assembly line to a line of code, and the many technologies that come in between—is the process by which technologies become meaningful in the eyes of social groups which, knowingly or unknowingly, engage in lengthy series of negotiations and contestations while the technology at hand is stabilizing. The social shaping approach, which is the primary approach taken in this work, emphasizes that technological development includes not only invention, testing, funding, marketing, use, versioning, improvement, etc, but more fundamental debates about the basic meanings of these processes and the artifacts they produce. The contestation and eventual stabilization of meaning and use is what ultimately shapes the technologies in the making, and the systems discussed here are no exception. While writing this dissertation, I have encountered the need to expand the basic Social Construction of Technology (SCOT) framework in order to better accommodate the systems under investigation. As the cases will demonstrate, expanding the existing concepts of artifacts, sites, social groups, and technological frames, allows me to deepen and broaden my explanations. Expansions to SCOT come from three directions. First, by accommodating a model developed by Larry Lessig, which discusses markets, norms, laws, and 'code' as four interactive modes of regulating human behavior. Second, by expanding the concept of 'affordances', a term used in cognitive psychology and information systems to discuss meaning-making processes by users who interact with technological systems. Lastly, by incorporating insights from identity theory, emphasizing the roles that identity-building practices play in these systems. Taken together the work will offer a version of SCOT that is better positioned to explain the growth and stabilization of large-scale participatory, networked information systems.

A fundamental premise of my work, then, is that ICTs can only be understood by simultaneously grasping their functional, discursive, and political dimensions, which are an inherent part of any meaning making process. In a book titled *The Closed World,* Paul Edwards explains why this is true for computers, and argues that in the beginning of the 'information age' computing and information technology were co-constructed with the society that perceived them.[9] Edwards argues that during the 1960s and 1970s social and cultural contexts shaped emerging computer technology as 'closed' systems, which, in turn, co-constructed the 'closed' society. The interactions between culture, politics, and computer technology were all part of what he calls the 'closed world discourse', which included language, technologies, and practices that together supported the visions of centrally controlled, automated global power at the time of the Cold War. Edwards's concept of closeness borrows from literary criticism. He explains: "a closed world is a radically bounded scene of conflict, an inescapably self-referential space where every thought, word, and action is ultimately directed back toward a central struggle."[10] Edwards argues that the opposite of this 'closed world' is not an 'open world' but rather a green world, an unbounded natural setting in which the limits of law and rationality are surpassed and which represents a magical, natural, transcendent space. Echoing this argument, but also moving beyond it, using the case studies I will demonstrate how in many ways Edwards's closed world discourse operates not only vis-à-vis a *green*-world alternative but also vis-à-vis an *open*-world discourse of cooperation, coordination, and collaboration. This argument

[9] Paul N. Edwards, *The Closed World : Computers and the Politics of Discourse in Cold War America*, *Inside Technology* (Cambridge, Ma: MIT Press, 1996).
[10] Ibid., 12.

expands on Fred Turner's discussion of "the forgotten openness of the closed world,"[11] which shows how the sites and projects that produced the closed world discourse were also breeding grounds of collaborative styles of work, collaborative rhetoric, and entrepreneurship. Turner argues: "even as they built the large military research projects and the massive weapons that would come to symbolize cold war technocracy, the researchers…carried forward a collaborative style and a rhetoric of collaboration."[12] He shows how this rhetoric and discourse were influential in shaping the counterculture of the 1960s and its actors' interpretations of what computers came to mean. Through the detailed analysis of said contemporary and historical case studies the following chapters trace the ways in which ICTs gain meaning in the eyes of the volunteers that came together to build them. Following Turner, in my discussion I focus on how openness and enclosure operate as two competing models in the social shaping of these information networks, always co-present to one another, pulling in different directions.

Outline of the rest of this work

Let me briefly outline the plan for this work.

Chapter 2 – Literature review. This dissertation aims to contribute to writing in the genre of social study of technology and at the same time inform public policy debates pertaining to ICTs. To do so it rests on several bodies of literature in history, anthropology, law, economics and sociology which, given their differences in methodology, audience, and focus, would not normally be read together. Chapter 2 reviews major works within this vast literature, which are foundational for this work.

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[11] Fred Turner, *From Counterculture to Cyberculture : Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism* (Chicago: University of Chicago Press, 2006), 16-28.
[12] Ibid, p. 28

First I examine the S&TS literature on technological systems, primarily Thomas Hughes systems' theory[13] and Bijker, Pinch and Kline's notions within SCOT.[14] I then look at several examples of works that investigated the role of volunteers and self-selected affinity groups within ICTs, including Julian Kilker's work on newsgroup standards,[15] and Atsushi Akera's work on IBM's SHARE project.[16] I then look at existing social-scientific literature on FOSS, mainly two recent works in cultural anthropology, Chris Kelty's book on free software and the Internet[17] and Gabriella Coleman's ethnography of a large Linux community.[18] Lastly I look at works in economics that offer both theoretical and empirical studies of open systems, starting with Yochai Benkler's account of 'peer-production systems',[19] continuing with Steven Weber's analysis of the success of open source[20] and finishing with Paul David and

[13] Thomas Hughes, *Rescuing Prometheus : The Story of the Mammoth Projects--Sage, Icbm, Arpanet/Internet, and Boston's Central Artery/Tunnel--That Created New Style* (New York: Pantheon, 1998).
[14] W Bijker, "The Social Construction of Bakelite: Towards a Theory of Invention," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. T. Hughes W. Bijker, & T. Pinch (Cambridge, MA: MIT Press, 1987), Wiebe E. Bijker, Thomas Parke Hughes, and T. J. Pinch, *The Social Construction of Technological Systems : New Directions in the Sociology and History of Technology* (Cambridge, Mass.: MIT Press, 1987), T. Pinch and W. Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. T. Hughes W. Bijker, & T. Pinch (Cambridge, MA: MIT Press, 1987), T. Pinch and R. Kline, "Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States," *Technology and Culture* 37 (1996).
[15] Julian Albert Kilker, "Networking Identity: A Case Study Examining Social Interactions and Identity in the Early Development of E-Mail Technology" (PhD Dissertation, Cornell, 1999).
[16] Atsushi Akera, "Volunteerism and the Fruits of Collaboration: The Ibm User Group Share," *Technology and Culture* 42, no. 4 (2001).
[17] Christopher M. Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet* (Cambridge, MA: MIT Press, 2006).
[18] Gabriella Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition" (PhD Dissertation, University Of Chicago, 2005).
[19] Benkler, *The Wealth of Networks : How Social Production Transforms Markets and Freedom*.
[20] Steve Weber, *The Success of Open Source* (Cambridge, Mass.: Harvard University Press, 2004).

Rishab Ghosh's comprehensive empirical surveys of the global free and open source software communities.[21]

Chapter 3 – FOSS. FOSS is the primary case study in this work. FOSS is a catch-all phrase for a set of technological artifacts, software development methodologies, and software code that are the focus of a mesh of advocacy groups, developer organizations, user communities, and, increasingly, commercial entities.[22] The chapter traces the history of the Free Software movement from 1984 to 2007 and the way in which it had risen to become one of the dominant trends in the computer sector today. This chapter focuses on understanding the modes of participation in FOSS and how these are tightly related to rhetorical moves that dominate meaning making in this system. FOSS demonstrates new models of social organization that are focused on self-organizing communities. These communities, according to their own members' rhetoric at least, represent a significant departure from earlier social structures and economic logic. How did the FOSS movement start? How did it grow? Who participates in it? Where does it stand today? What are the structures of participation that govern FOSS projects? The chapter will answer all these questions

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[21] Paul A. David, Andrew Waterman, and Seema Arora, *Floss-Us - the Free/Libre/Open Source Software Survey for 2003* [Web] (Stanford Project on the Economics of Open Source Software, September 2003 [cited December 15th 2006]); available from http://www.stanford.edu/group/floss-us/report/FLOSS-US-Report.pdf, Rishab Aiyer Ghosh, *Free/Libre and Open Source Software: Survey and Study* [Web] (International Institute of Infonomics University of Maastricht, The Netherlands, June 2002 [cited December 15th 2006]); available from http://www.infonomics.nl/FLOSS/report/, Rishab Aiyer Ghosh and Paul A. David, *The Nature and Composition of the Linux Kernel Developer Community: A Dynamic Analysis* [Web] (SIEPR-Project, February 21st 2003 [cited December 24th 2006]); available from http://scholar.google.com/url?sa=U&q=http://dxm.org/papers/licks1/licksresults.pdf.

[22] The history of the free and open source movements is detailed in several books and articles, most famous of which is Chris DiBona, Sam Ockman, and Mark Stone, *Open Sources Voices from the Open Source Revolution* (Beijing ; Sebastopol: O'Reilly, 1999). The open source organization homepage proposes a history at history of the OSI see *History of the Osi* [Web] (Open Source Initiative, 2006 [cited November 15th 2006]); available from http://www.opensource.org/docs/history.php. The history of Linux is outlined in Glyn Moody, *The Rebel Code : The inside Story of Linux and the Open Source Revolution* (Cambridge, Mass.: Perseus Pub., 2001).; and in Linus Torvalds and David Diamond, *Just for Fun: The Story of an Accidental Revolutionary* (New York: HarperBusiness, 2001).

and start to outline the parameters and principles that I will emphasize as reoccurring features of openness in the other case studies as well. My main argument in this chapter is that FOSS represents a class of participatory information networks which are open to volunteer participation and which are based on alternative conceptions of property. To this end, FOSS exhibits significant discontinuities from earlier software systems that can be transformative. At the same time, in a process that I will outline as cooptation, incumbents in the computer industry are now annexing FOSS, imbuing the system with different meanings of openness and freedom, and attenuating FOSS's transformative potential.

I have chosen FOSS as the longest, and primary case study in my work since I believe it best represents the overall argument of my work and allows me to identify the key elements that reoccur in the other case studies as well. Software is also my area of expertise and the domain in which I have gained significant participation and observation experience (see section on methodology below). Chapter 3, thus, sets the ground for the rest of the work, identifying the key theoretical components and outlining the structure for the following case studies.

Chapter 4 – ARRL. This chapter brings us back to the beginning of the twentieth century as it tells the story of the American Radio Relay League (ARRL), a national radio relay-messaging network that was established in 1914 and spanned the entire continental United States. The ARRL was started and operated by radio amateurs who cooperated in order to overcome the technical barriers of short-wavelengths transmissions. The language used to encourage participation in this grass-roots network called specifically for new modes of social organization. In my investigation of this case I focus on the processes by which the ARRL demonstrated the power of an alternative social structure in overcoming perceived technological limitations. I show how collaboration and participation become important principles in the social negotiations around a technology, and how these principles are used in the actors' attempts to influence government regulation of a technology during the process of its stabilization.

I have selected the ARRL's case in order to show that many of the themes that are being discussed are not limited only to the end of the twentieth century or the rise of the Internet as a dominant force in information technology. Particularly, the case demonstrates the intricate interconnections that exist between technology and regulation, the code and the law. The tension between regulation by law and regulation by code is a reoccurring theme that applies to all other case studies, and especially to FOSS. To this end, the ARRL serves as a historical mirror for FOSS, demonstrating how regulation is changed by and changes social structures.

Chapter 5 – GOC. This chapter explores how from 1948 to 1958 the U.S. military established and operated the Ground Observer Corps (GOC). Faced with a Soviet threat and realizing that sealing off U.S. airspace using automated radar systems alone was not possible, the Army Air Force decided to turn to volunteers in order to monitor the sky. In its full capacity the GOC enlisted hundreds of thousands of volunteers in dozens of communities all over the country. For six years, GOC posts monitored the sky until in 1958 newly developed radars could do the job. The GOC was a participatory system that was based on the principles of volunteer labor. Using this case study I argue that the establishment of an alternative social regime can facilitates a reduction in the barriers of participation. In the case of the GOC massive participation was perceived as a social solution to a threat for which a technological solution was not readily available. As I argue throughout the work, an emphasis on participation is a characteristic of many other open systems as well.

I have selected this case study for the contrast it offers to the other case studies that accentuates the continuities and discontinuities between 'open' and 'closed' systems. Unlike the other cases, in which communities of individuals self-organize for fun or technical challenges, the GOC was centrally organized and participation in it was first and foremost motivated by local patriotism and fear. To this end the case of the GOC demonstrates that some of the key tensions in open systems pertain to overcoming the challenges of large-scale cooperation and collaboration. Without the ability to pay for the observers' time and effort, like in a price-based market-based system, or the ability to command them, as in an army-like system, the GOC administrators were always struggling to recruit more volunteers and to keep the ones they had on staff. For this reason, the GOC relied on organized attempts to accredit and compensate GOC volunteers using a formal reputation system that included certificates, medals, and honorary lifetime memberships in various military organizations. The case thus demonstrates how reputation becomes essential for the maintenance of volunteer-based social structures. As it turns out, mechanisms of reputation management and the recording of contribution are chief features of open systems that return time and again, and this case helps explain the tensions between money, reputation, and managerial commands as organizing principles of a large volunteer workforce.

Chapter 6 – BIOS. This chapter investigates the case of Biological Open Source (BIOS), a recent initiative that tries to replicate the success of free and open source software in the fields of biology and agriculture. BIOS is a notion developed by activists and technologists that are explicitly importing the methods and metaphors of FOSS in order to spur agricultural and biological innovation. In many ways their efforts are a reaction to two inter-related processes of the global agribiotech sector, namely the proprietarization and technoligization of the field. This chapter explores the principles of participation in a system that aims to produce real-world artifacts and not just information. My argument focuses on analyzing the changes to the an 'open' system that occur when models for volunteer work are copied from the world of software development into biological wet labs and rice fields that eventually have to produce tangible goods in the form of, say, DNA, bacteria, and seeds. Overall, the case study allows me to better understand the stakes in the battle between the two competing models, and the ways in which a combination of technology and regulation intertwine.

I have selected BIOS as a case study for two main reasons. First, in order to show that the notion of participatory information networks today extends beyond software or communication. Like many other areas within the 'global information economy' agriculture is being influenced by advances in ICTs, and as such is subject to the same competing forces that influence traditional ICTs. By its own actors' accounts, BIOS offers direct historical continuities to FOSS from which it draws inspiration as well as legal, social, and technical structures. To this extend, the chapter shows how systems like BIOS can be better understood in connection to other ICTs. The second reason I chose this case is because it is historically recent, and because many of the issues are still being debated. By investigating a case while it is still 'hot' the analyst gets a chance to see the stabilization of a technology in the making. To this end I'm trying to peep into the black box of biotechnology, a much-debated area, before it is fully closed.

Chapter 7 concludes the work by exploring the commonalities and differences among the case studies and identifying the differences between 'open systems' as an ideal type, and my findings from the field. The commonalities I identify do not imply that there is direct continuity among the different systems but, rather, outline regulatory regimes that effect openness, or categories within which I explore the negotiations between openness and enclosure. These include changes to social structure, economic logic, conceptions of property, and notions of expertise. Taken together, I argue, these shifts entail great promise, but also great peril, demanding attention from anyone that cares about the future of our society. Chapter 7 also identifies directions of future research, outlining some of the larger meanings of open systems for democracy.

By the end of the work it is my hope that the reader will have a good understanding of the issues at stake and a good framework for exploring similar systems. There are many other cases in our time that I could have chosen, but due to scope and focus limitations I could not include them all. Particularly, cases like Wikipedia, a volunteer based encyclopedia, or arXiv.org, an open system for publishing, come to mind when thinking of participatory information networks. It is my hope that my work here can benefit the understanding of these systems by offering the reader a guideline to the issues, units of analyses, and operating principles of these and similar systems.

Methodology

As discussed above, this work is committed to a social constructionist methodology that places an emphasis on the meaning that relevant social groups ascribe to a technology. As such, I hope to unearth meaning making processes in both primary and secondary sources. In addition to a thorough engagement with relevant secondary literature in Chapter 2 (as well as in the case studies), the work relies on four types of primary sources.

Interviews

One of the primary research methods was a set of semi-structured interviews. These interviews were conducted at various locales or online via phone or email. (See appendix for full list). From the interviews I tried to construct a general understanding of open systems, focusing on the motivations of participation, the attitudes expressed by people involved in the early stages of system building, and the social structures that co-developed with the technology. Many of my interviews tried to raise questions concerning points of controversy along the way and tried to resurrect memories of hot debates and disagreements among open system participants in hope to go back to the phase in which technology was not yet molded and from which one could tease out the different approaches to open systems.

Textual Sources

I used the following types of sources: media coverage of open systems, internal communications among open system participants (primarily transcripts from archives of online discussion groups and newsletters), journal articles, advertisements and press releases by companies and organizations that were involved with (or threatened by) open systems as they appeared mostly in trade journals, court cases, and transcripts of hearings before Congress where open systems where being debated. Archival work was the primary source for the two historical case studies explored in chapters 4,5 (the American Radio Relay League, and Ground Observer Corps). For these cases I relied on Congress hearing transcripts, news publications and media coverage, advertisements and promotional material, and internal publications that were used to communicate with members of relevant organizations at the time of their operation. Data was gathered from the ARRL archives, several presidential libraries, private collections, and the National Archives in Washington, D.C., as well as from secondary sources.

Participant observation

Among other sins, I am a trained computer scientist and an entrepreneur who started software companies and participated in closed and open source software development for several years. As such, I had the opportunity to gain first-hand experience of the ICT innovation process. Several of the ideas explored and explained in this work stem from the innumerable hours spent with suppliers, partners, and customers of the companies with which I was involved as an employee, manager, or consultant. Such interactions took place over several years during business meetings, presentations, trade-shows, and many caffeinated hours poring over computer monitors in software labs in various places around the world where the local language was C++, Java, or PHP. Endless hours in airport terminals and airplanes on the way to trade shows or customer meetings provided more than enough time for reflection. I have not conducted any participant observation in biology, but to bring myself up to speed, I've spent a period of time at biotechnology labs where traditional, non-open methods for genetic engineering were used, in addition to the time spent with open source biology advocates, particularly the avid employees of BIOS.

"Going native" is often considered a primal sin in the social sciences. The maintenance of the analytic distance, it is believed by some, is a pre-requisite for ensuring that there is no bias in judgment and that the conclusions are intellectually honest. While respecting this view, I believe that being able to cross the chasm that exists between actors and analysts has taught me valuable lessons. Reading about technological systems is not the same as participating in them, just like reading about a bicycle race is not the same as being on the track. Participation in FOSS is an experience that gave me a very grounded understanding of open systems and what's at stake in ways that are different from hearing the same from other actors. I have been lucky enough to experience and gain both sorts of perspectives.

More than anything else, participant observation has taught me that there needs to be a balance between openness and enclosure. American baseball legend Yogi Berra once observed that in theory there is no difference between theory and practice but in practice there is. The same rule applies here. Whereas theoretical accounts tend to mark clear lines, from a practical point of view, sometimes mixing a patent strategy with open source software makes sense; sometimes using proprietary and non-proprietary systems is a middle ground. In a way, many of the theoretical arguments of this work are a long route that explains what I learned by juggling many balls in both closed and open systems, mainly in the software industry.

CHAPTER 2:

THEORETICAL FOUNDATIONS AND LITERATURE REVIEW

As I outlined in the previous chapter, this dissertation aims to contribute to writing in the genre of social study of technology and at the same time to inform public policy debates pertaining to ICTs. My work resonates with several bodies of literature in history, anthropology, law, economics and sociology which, given their differences in methodology, audience, and focus, would not normally be read together; this chapter situates my dissertation among about a dozen of these. Clearly, the list of books and articles that are reviewed hereunder is not exhaustive—hundreds of other works are cited throughout the following chapters—however, the works surveyed here are the ones I found most useful as foundations for my own work.

This chapter starts with a short review of the S&TS literature on the social construction of technological systems, particularly the works of Bijker, Pinch and Kline, and their notions of social groups, technological frames, closure, user resistance, and foundational units of analysis in my work.[1] I then look at Thomas Hughes's systems' theory and the concept of heterogeneous engineers that help explains some of the key people presented in the case studies.[2] I then expand on two examples of social-historical works that applied these S&TS concepts when they investigated the role of volunteers and self-selected affinity groups within ICTs, Julian

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[1] Bijker, "The Social Construction of Bakelite: Towards a Theory of Invention.", Bijker, Hughes, and Pinch, *The Social Construction of Technological Systems : New Directions in the Sociology and History of Technology,* Pinch and Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other.", Pinch and Kline, "Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States."

[2] Hughes, *Rescuing Prometheus : The Story of the Mammoth Projects--Sage, Icbm, Arpanet/Internet, and Boston's Central Artery/Tunnel--That Created New Style*.

Kilker's work on the creation and stabilization of email standards,[3] and Atsushi Akera's investigation of IBM's SHARE project, an early code-sharing endeavor.[4]

The chapter continues by looking at two recent works in cultural anthropology, Chris Kelty's book on Free Software and the Internet[5] and Gabriella's Coleman ethnography of a large Linux community.[6] Lastly I look at works in law and economics that offer both theoretical and empirical studies of open systems, starting with Yochai's Benkler account of 'peer-production systems',[7] Janet Hope's study of Open Source Biotechnology,[8] Steven Weber's analysis of the success of open source,[9] and Paul David and Rishab Ghosh's comprehensive empirical surveys of the global free and open source software communities.[10] The chapter ends by identifying the gaps in the existing literature that my work tries to address.

Social Constructivism and Technological systems

First and foremost, my work is a thesis in the tradition known as the Social Construction of Technology (SCOT) as characterized by Bijker et al.[11] In the main, works in this genre argue that technological innovation is not the result of mythical men who introduce new 'technologies' and release them into 'society,' starting a

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[3] Kilker, "Networking Identity: A Case Study Examining Social Interactions and Identity in the Early Development of E-Mail Technology".
[4] Akera, "Volunteerism and the Fruits of Collaboration: The Ibm User Group Share."
[5] Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*.
[6] Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition".
[7] Benkler, *The Wealth of Networks : How Social Production Transforms Markets and Freedom*.
[8] Janet Elizabeth Hope, "Open Source Biotechnology" (PhD Dissertation, Australian National University, 2004).
[9] Weber, *The Success of Open Source*.
[10] David, Waterman, and Arora, *Floss-Us - the Free/Libre/Open Source Software Survey for 2003* ([cited 12/04/08]), Ghosh, *Free/Libre and Open Source Software: Survey and Study* ([cited 12/04/08]), Ghosh and David, *The Nature and Composition of the Linux Kernel Developer Community: A Dynamic Analysis* ([cited 12/04/08]).
[11] Bijker, Hughes, and Pinch, *The Social Construction of Technological Systems : New Directions in the Sociology and History of Technology*.

series of (un)expected impacts; rather, technological innovation is a complex process of co-construction of both technology and society, to the degree that they could even be conceived separately of one another. In this process actors negotiate the meaning of new technological artifacts, alter technology through resistance, and construct social and technological frames of thought, practices and actions. This work will add to the growing social constructionist writing that investigated the invention, implementation, and stabilization ICTs such as radio,[12] the telegraph,[13] the telephone,[14] and the Internet.[15] In this work I tell the stories of said systems from the various vantage points of "relevant social groups", which are the basic units of analysis. According to Pinch and Bijker, a social group becomes relevant to the analysis when the artifact or system at hand gains some meaning in the eyes of that group or poses a problem to it. To this extent, a 'problem' is a 'problem' only inasmuch as there is a social group that perceives it as such.[16] Social groups engage in battles over the *meaning* of systems and artifacts, exhibiting what SCOT calls 'interpretive flexibility.'[17] Such flexibility is exhibited in the interpretation of what the system means, what it is good for, what constitute facts and theories concerning the system and its artifacts, etc. In other words, nothing about the system can be taken for granted, almost any of its characteristics is subject to interpretation, including what otherwise might be

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[12] Susan J. Douglas, *Inventing American Broadcasting, 1899-1922* (Baltimore: Johns Hopkins University Press, 1989), Susan J. Douglas, *Listening In : Radio and the American Imagination, from Amos 'N' Andy and Edward R. Murrow to Wolfman Jack and Howard Stern*, 1st ed. (New York: Times Books, 1999).
[13] Gregory John Downey, *Telegraph Messenger Boys : Labor, Technology, and Geography, 1850-1950* (New York: Routledge, 2002), Carolyn Marvin, *When Old Technologies Were New Thinking About Electric Communication in the Late Nineteenth Century* (New York: Oxford University Press, 1988).
[14] Claude S. Fischer, *America Calling : A Social History of the Telephone to 1940* (Berkeley: University of California Press, 1992).
[15] Janet Abbate, *Inventing the Internet*, *Inside Technology* (Cambridge, Mass: MIT Press, 1999), Sherry Turkle, *Life on the Screen : Identity in the Age of the Internet* (New York: Simon & Schuster, 1995).
[16] Pinch and Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," 30.
[17] Ibid.

considered hard technical facts. This does not mean, however, that ‘anything goes’ or that materiality or physics don’t matter; they obviously do, and within a given contexts they make certain things easier or harder to do, but the perception of these limitations in and of itself is subject to social negotiation. Moreover, for an agreed upon meaning to emerge, the members of a social group have to share a certain mindset, a notion that in the social constructionist tradition is captured with the concept of ‘technological frames.’ Unlike analytical categories such as ‘technological style’, ‘technological tradition’, and ‘technological paradigm,’ which are centered on engineering communities, Bijker defines a technological frame as “a frame with respect to technology, rather than as the technologist’s frame.”[18] Different actors can hold technological frames, whether they are inventors, government officials, business people or any other members of any relevant social group.

Participation in a technological frame guide the ways in which the actors understand the systems’ goals and the ways they interpret and understand the key problems said systems solve or create. Frames also suggest the appropriate problem-solving strategies, the requirements that need to be met by problem solutions, the relevant theories that need to be applied, and more.[19] Importantly, actors can belong to more than one technological frame at any given time. Moreover, inclusion in more than one frame becomes a source of innovation, since actors are able to offer new solutions to outstanding problems given their alternative world-view. Bijker argues that

> [A] technological frame structures the interaction of members of a social group. But it can never do so completely: first, because different actors will have different degrees of inclusion in the frame (actors with a high inclusion interacting more in terms of that technological frame

[18] Bijker, "The Social Construction of Bakelite: Towards a Theory of Invention," 172.
[19] Wiebe E. Bijker, *Of Bicycles, Bakelites, and Bulbs : Toward a Theory of Sociotechnical Change* (Cambridge, Mass.: MIT Press, 1995), 125.

> and actors with a low inclusion to lesser extent), and, second, because all actors will in principle, be members of more than one technological frame.[20]

Eventually, the meaning negotiation process involves the stabilization of perceived notions and the establishment of consensus about what these systems are good for, what can be done with them, and what their outcomes signify. When such stabilization occurs, social constructivists see the attainment of 'closure.' Pinch and Bijker explain: "closure in technology involves the stabilization of an artifact and the 'disappearance' of problems. To close a technological 'controversy,' one need not solve the problems in the common sense of that word. The key point is whether the relevant social groups see the problem as being solved."[21] As I will demonstrate in the following chapters, the first three case studies end with the reaching of (temporary) closure, and the ostensible stabilization of meaning, however, I will show that the 'open' nature of the participatory systems described below, sometimes puts the very notion of closure into question.

Tom Hughes's System Theory

While largely consistent with SCOT, Thomas Hughes offers an alternative theory on technological systems that he calls the "systems' approach". Where SCOT offers very useful guidelines and heuristics for analyzing the emergence and stabilization of technological artifacts, Hughes theory is, in my view, better situated to explain larger and more complex technological systems. According to Hughes's theory the innovation process should be understood as happening largely within a system, which is dominated by 'system builders' who are often, but not always, engineers that are able to internalize not only technological factors but also social,

[20] Bijker, "The Social Construction of Bakelite: Towards a Theory of Invention," 173.
[21] Pinch and Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," 44.

economic, political, and legal aspects. Hughes argues that ‘system builders’ are much more than inventors or managers:

> System builders preside over technological projects from concept and preliminary design through research, development, and deployment. In order to preside over projects, system builders need to cross disciplinary and functional boundaries--for example, to become involved in funding and political stage-setting. Instead of focusing upon individual artifacts, system builders direct their attention to the interfaces, the interconnections, among system components. Further, system builders often preside over the establishment of systems that involve both physical artifacts and organizations.[22]

To a large degree, people like Maxim, Stallman, Torvalds, and Jefferson, the key actors that are presented in the case studies, are all system builders. In analyzing their actions, and the very conception of a ‘system’ per se, I rely directly on Hughes’s definitions. However, in Hughes’s systems, the inter-working parts are usually government agencies, funding organizations, NGOs, corporations etc. In my stories those actors exist as well, but the system builder also has a significant role in managing the community of individual developers and contributors. To this extent some of the role of an ‘open system’ builder can be described less as presiding over large infrastructure and more as ‘herding a pack of cats’, as Linus Torvalds famously put it.[23]

Moreover, foundational works within S&TS have recognized two skeletons upon which the bodies of technological innovation can rest. The first, like the cases Bijker describes, involves a model of invention whereby an individual or corporate inventor proposes an idea, secures funding, builds a prototype, tests early versions,

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[22] Hughes, *Rescuing Prometheus : The Story of the Mammoth Projects--Sage, Icbm, Arpanet/Internet, and Boston's Central Artery/Tunnel--That Created New Style*, 7.

[23] Steve Hamm, *Linus Torvalds' Benevolent Dictatorship* [Web] (BusinessWeek Online, August 18th 2004 [cited December 26th 2006]); available from http://www.businessweek.com/technology/content/aug2004/tc20040818_1593.htm.

performs marketing activities, develops further versions and sells them within the market and so on and so forth. Ostensibly, most of our everyday technologies were—and still are—developed in this way (consider cars, airplanes, telephones, personal computers, and most software) The second model, like in the cases Hughes describes, proposes centralized innovation whereby funding by large organizations (like universities or government agencies) drives basic research, which is later refined into working products or applied technological outcomes using a system's engineering approach (think of the highway system, missile defense, or the early Internet.) There are other cases in the S&TS literature that investigated a third model in which the drivers for innovation are not governments or firms but communities of peers which are loosely connected and partake in large-scale collaborative projects. In these cases coordination is not governed by market signals and is not organized by hierarchical managerial structures but, rather, by self-selection of tasks based on a diverse set of motivations of which money is only one. von Hippel and von Krogh discuss the open model as a middle ground between a "private investment" model where returns to the innovator result from private goods and efficient regimes of intellectual property protection and a "collective action" model that assumes that under conditions of market failure, innovators collaborate in order to produce public goods. [24]

Two such cases that are pertinent to my work are the development of email, and the establishment of computer user groups. As I will show, the nature of these systems and the diverse motivations of the actors involved in them requires enhancements of the traditional S&TS analytical approaches so that they can better assess the central role that reputation and identity building play in the new systems.

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[24] Eric von Hippel and G. von Krogh, "Open Source Software and the 'Private-Collective' Innovation Model: Issues for Organization Science," *Organization Science* 14, no. 2 (2003).

Julian Kilker – Identity building through technology

Julian Kilker's primary objective in his PhD dissertation, which investigated the history of the emergence of email standards, is "to develop a theoretical framework for examining communication technology development from the viewpoint of identity."[25]

Kilker's theory explains how email, that was designed and implemented by a small, elite group of computer experts, for their own needs (within the ARPA standards), could become so widely adopted. The explanation hinges on Kilker's observation that online discussion groups, the primary mechanism for the negotiation of email protocols, were tools that allowed multiple groups to easily interact, for participants to build their identity beyond their core group, and for individuals and groups to shift their agendas over time, very easily. Kilker's findings show that through these online discussion boards, the computer scientists and government administrators, which were involved in email protocols' development, were able to express their interest in social issues pertaining to both their own peer group and society at large. Although the groups' discussions did not necessarily help reach early closure, which in this context was to a large degree achieved by ARPANET funding decisions, it helped bring many other interpretations of email into the discussion.[26]

Kilker argues that existing theories in communication cannot properly explain the early days of emerging communication technologies and have a hard time explaining the gaps that exist among design and use contexts in such settings. He proposes to enhance the SCOT approach with social identity theory (SIT). The reason that such a theory is needed, Kilker argues, is because when describing emerging

[25] Kilker, "Networking Identity: A Case Study Examining Social Interactions and Identity in the Early Development of E-Mail Technology", 15.
[26] Ibid., pp 243-246

communication technologies like radio, email or the Internet in general, there are several factors that complicate making any theoretical claims within existing frameworks. These factors include:

a. the regulatory, political and social contexts, are often in great flux at this stage that goes beyond alternative uses and relationship between relevant social groups;
b. these technologies are highly flexible in social terms, and acquire very different meanings at the same time;
c. it is hard to identify specific contexts, as there is no organizational context with enforced usage and existing relationship;
d. models within communication theory tend to focus on mass communication
e. many models are technologically deterministic.

Using a SCOT approach alone to solve these challenges is not enough, because the very definition of the relevant social groups is problematic at this stage, when some of the 'groups' are not more than a few individuals. In those cases, identity becomes an important factor. Kilker argues that "using social identity theory highlights the difficulty of overcoming social considerations in technology design. Examining the social identities of groups involved in technology development can help us better understand collaborative development and develop more realistic expectations for it processes and outcomes."[27]

While in this dissertation I will not investigate SIT thoroughly, I acknowledge the challenges that he outlines, and take from him one key idea: in systems like the ones I study here, identity building becomes a crucial factor, and needs to be accounted for analytically. Kilker writes:

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[27] Ibid., p. 267

> …examining social groups not only as defined in terms of their interpretations of the technology (as the social construction of technology requires but defined by the analyst) but also in terms of social identifications (based on an analysis of the actors' categorizations). While there may be a large overlap between these definitions of groups...social identifications will stereotype, polarize, and shift group boundaries in ways which provide important implications for 'closure'[28]

Building on this idea, I will show how an 'open source' style system closure is a problematic concept to the degree that participants are always presented with the opportunity to re-build their identity anew. As I will show, this situation arises when participants' technical identities become a significant, if not an all-encompassing, part of who they are.

Several other S&TS works explore the idea of 'technical identity'. Kristen Haring, for example, defines this term, and explains how at one and the same time, some people choose to identify with a technology while technologies possess identities. The double meaning, she argues, "suggests an important connection between the two senses of technical identity, namely that the technical identities of machines and people are co-produced."[29] More recently, Christina Dunbar-Hester discusses further layers of actors' identity in the context of low power FM radio activism. Radio tinkering, as we know, operates with a backdrop of a long history as a masculine undertaking and a site of masculine identity construction. Dunbar-Hester argues that her actors' geek, activist and gendered identities interplay with one another, crating tension.[30] She writes:

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[28] Ibid., p. 247
[29] Kristen Haring, "The "Freer Men" of Ham Radio: How a Technical Hobby Provided Social and Spatial Distance," *Technology and Culture* 44, no. 4 (2003): 739.
[30] Christina Dunbar-Hester, "Geeks, Meta-Geeks, and Gender Trouble: Activism, Identity, and Low Power Fm Radio," *Social Studies of Science* 38 (forthcoming 2008).

> …geek identity, activist identity, and gender identity are all mutually involved, and are performed and constructed together around work with LPFM. The construction of geek and activist identities both share participatory ideals, for example, but geek identity incorporates a sense of identification with a technology that activist identity alone lacks. And geek identity as I have defined it relies on a political engagement with technology that hackers may lack; thus for these actors, technical affinity may enhance activist identity, deeply binding these actors' social justice values to a site of technical work.

In my discussion below I expand on the importance of identity construction in open systems. (See also discussion of Coleman's work below).

Atsushi Akera – Volunatarims and collaboration in an industrial setting

In an article titled *Voluntarism and the Fruits of Collaboration*, Atsushi Akera investigates The IBM User Group, Share which operated in the second part of the 1950s and in many regards was a pre-cursor to the FOSS phenomenon.[31] Akera explains how *Share,* the first nationwide computer user-group developed and how it became a mediator between IBM and a community of semi-volunteers. With the backdrop of Cold War politics and the stabilization of computer programming as a new profession, Share was originated by a group of computing-centers directors in Southern California's aviation industry, who believed that cooperation and collaboration among early IBM mainframe users could reduce high labor costs, help overcome the shortage in skilled programmers, and increase the efficiency in which computer programs were written and used. Akera argues that despite fierce competition in that industry sector, a culture of practical cooperation had developed over the years of World War II when companies all worked together for the national cause, and thus firms like Boeing and Lockheed Martin were quick to forge alliances when they saw the opportunity of improving the efficiency of their computer

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[31] Akera, "Volunteerism and the Fruits of Collaboration: The Ibm User Group Share."

departments. Moreover, Akera argues that "the principal motive for collaboration was the poor quality of the programs IBM had written for the computer."[32] Such programs included the 'assembler', a software component that was able to translate mnemonic codes into binary, and the programs that actually did computations and were fed to the assembler. Not only was the quality of the programs poor, IBM also expected that each customer would write their own programs anew, and this was clearly inefficient, as the same work had to be replicated over and over again. To solve these problems, representatives from eighteen companies got together in August 1955 at the Rand Corporation, and established Share with the idea that such cooperation would yield a better assembler and would promote program exchange.[33]

> Share represented the culmination of longstanding efforts at cooperation by its founding members, rather than their beginning. By establishing an organization located logically between IBM and its customers, Share was poised to garner the resources it needed for a substantial collaboration in computer programming.[34]

Akera argues that for many of Share's participants, mostly computer-center directors and their senior staff, group activities like meetings, talks, and distribution of printed proceedings, were an opportunity to explore organizational models that were different from their hierarchical firms. In Share meetings, concerns about hierarchy often gave way to a sense of participation, and some participants took great pride in cooperating so closely with representatives from competitive firms.[35] Over time the members of the group were starting to develop a shared technical and professional identity. All of them were paid employees of large corporations, but their activities within Share went well beyond the call of duty, relying heavily on participant's sense

[32] Ibid., p. 714
[33] Ibid., p. 715
[34] Ibid., p..716-7
[35] Ibid., p. 717

of volunteerism. In addition, as some of the participating firms' legal counsels had opined, the coordination of programming effort entered a grey area of anti-trust law and could in some cases be considered anti-competitive. To overcome this legal challenge, Share representatives started making explicit use of the rhetoric of voluntarism.[36]

Soon however, the small group mentality started to outgrow itself. Share expanded from eighteen to well over a hundred members in just three years, and this required a change in attitude and organizational structure. Initially Share was based on a principle of self-selection of tasks, where each firm decided for itself which programs it would write, but as the number of members grew, the original members felt that things were falling out of control, and they had proposed a committee structure that would bring order to the work. As a result, Share was acquiring a bureaucracy and a rationalized organizational structure.

> Initially, common technical interests and a need for collaboration had overcome individual differences. But as Share grew and its agenda became more diverse, new tensions appeared. Far from being destructive, these forced a set of organizational changes that allowed the group to remain an effective intermediary between IBM and its customers. In making this transition Share continued to draw upon familiar organizational models. Its general meetings came to resemble even more closely conferences held by established professional societies.[37]

In addition, as *Share* grew the task of distributing the programs became burdensome, and IBM started playing a greater role in facilitating the organization's infrastructure with both staff and material resources, a task it was happy to do, since,

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[36] Ibid., p. 728. As discussed above, and will be discussed further in Chapter 3, the use of specific rhetoric serves to define the meaning of the technology. By using the rhetoric of voluntarism Share participant defined the meaning of Share not only to regulators but also to themselves. In Chapter 7 I discuss the connection of this rhetoric and the ideology of openness.

[37] Ibid., p. 721

as Akera notes, better computer programs sold more computers. Over time IBM supplied the support for maintaining the program library, distribute the proceedings and facilitate the meetings. This came at a time when Share participants were beginning to realize the limits of voluntarism and the difference between fostering an open program exchange and coordinating an elaborate software development plan. Share faced two organizational options: (1) it could continue as an "organization in which each installation contributes what it wishes in the way of programs and information," [38] or (2) it could have "some volunteers participate in a powerful new 'working committee' that had the authority to coordinate program development based on its assessment of each member's needs."[39] Share's early members preferred the latter path, believing that the norms of the organization were strong enough and that members will deliver what the committee assigned them, although it had no bureaucratic authority over them. It turned out that this was not always the case. The mainframe computer world was on the verge of a sea change in software with the introduction of Fortran, a high-level language that represented a different approach to system programming, and which, for technical reasons, took the wind out of Share's sails as it rendered assembler level programs all but obsolete, and consequently diminished the motivations for sharing them. Despite this fact, Share still had an important role in the development of computers and their programmers. Akera summarizes:

> Share created not only a body of knowledge about programming but also an organization with a body of practices for creating this new expertise. … Share's technical efforts were an important means of transforming the social relations surrounding computing facilities. Computing center directors and systems programmers were able to enhance their positions by specifying different kinds of knowledge,

[38] Ibid., p. 732
[39] Ibid., p. 732

> delimiting Share's collective sphere of activity, and adding to the base of knowledge that reinforced their own views about efficiency …This is not to say that those affiliated with Share could operate outside the politics of the workplace. The collective, technical efforts of Share altered the balance of negotiation, but the group was not immune to external developments. The limits of voluntarism left Share vulnerable to the autonomous decisions of end-users and to independent work by IBM. The rise of Fortran forced systems programmers to redefine not only their role but also their expertise.[40]

In summary, Akera's account serves as a stable baseline from which I can start observing the continuities and discontinuities in open systems' development. Share demonstrates many of the principles that would become prominent in FOSS and BIOS four decades later, including two key drivers of such large-scale collaborative systems: (1) an attempt by the industrial order to pool and hedge resources in order to gain increased efficiency, and (2) enthused participation of volunteers that find in such collaborative practices a locus for building their technical identity. Like in Share's case, these dual motivations are often in conflict, and as I explore in more detail in the case studies that follow, recognizing the tension between them is essential when mapping the ways in which collaborative systems unfold. Another important aspect in Share that reoccurs later is the tension created for economic logic when cooperation proves more economically efficient than competition. I will analyze this point in more detail in the discussion of Benkler's theory below, suffice it to note now that IBM was among the first firms to understand that, as Akera's poignantly points out, software becomes a driving force for selling hardware and services, and has been an active player in this field for half a century since. Lastly Share serves as an interesting comparison point when I discuss the limits of voluntarism. One of the wonders of FOSS is the way it was able to scale up. In Share, once the group grew beyond a certain size, collaborators chose to resort to traditional organizational structures, and to

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[40] Ibid., p. 735

rely on IBM's infrastructure in order to enable collaboration. As all four case studies will demonstrate, particularly FOSS and BiOS, scaling up is one of the most significant problems that these systems under investigation face. The problems that Share encountered will help us better understand the novelty that FOSS models offered when they overcame the problem of scale using technical, social, and legal mechanisms.

Cultural Anthropology approaches to free and open source systems

In the cultural-anthropology literature, two accounts serve as stepping stones for my work: Chris Kelty's forthcoming book *Two Bits: The Cultural significance of Free Software and the Internet*[41] and Gabriella Coleman's Ph.D. dissertation, *The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition*, an ethnography of *Debian*, the largest Linux community.[42]

Chris Kelty –The rise of FOSS and the Internet

Kelty's work offers an empirical study of the rise of FOSS and the Internet since 1983, as well as a theoretical framework that helps explain it. Kelty engages with the two key issues of my work: open systems and free and open source software, and as such it is probably the closest work to mine in terms of scope and concepts. Kelty argues that FOSS is an example of a broad shift in the structures of power, technology, markets, and corporations that extends well beyond the realm of software and into other domains like science, education, politics, and economics and many other fields that depend on the creation, dissemination and authorization of knowledge. Kelty analyzes the cultural significance of FOSS and the meaning and

[41] Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*.
[42] Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition".

value of FOSS practices using an analytical term that he coins--'recursive publics'. A recursive public, Kelty argues, "is a public that is vitally concerned with the material and practical maintenance and modification of the very means of its own existence as a public, as a collective independent of other forms of constituted power."[43] In other words, the same forces that in software demand keeping the source 'open' and software 'free', come to bear as part of a political process that aims to ensure that the structures of power remain balanced in specific arrangements. "Recursive publics are publics concerned with the ability to control, modify and maintain the infrastructure that allows them to come into being in the first place, and which in turn, constitutes their everyday practical commitments and their identity as creative and autonomous individuals."[44] In the case of FOSS, Kelty shows, the underlying infrastructure with which the 'public' is concerned is constituted around technologies that together became what is now called the Internet, including usenet newsgroups, email, Unix and Unix-derived programs, and primarily the World Wide Web.

Kelty is concerned with how the relationship between 'geeks', 'free software' and the 'Internet', came to be, and how this story relates to the concept of 'openness' writ large. He writes:

> Between 1980 and 1993, no person or company or computer industry consortium explicitly set the goal of "openness" as that which organizations, corporations or programmers should aim at, but by the same token, nearly no one dissented from the demand for openness. Everyone seemed to want some kind of "openness"—not only amongst manufacturers, but also amongst customers, from General Motors to the armed forces. The debates about the meaning of open systems—both rhetorical and technical—have produced a slough of writings…The definitions [of openness] stress different aspects, from interoperability of heterogeneous machines to compatibility of different applications, to

[43] Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*, 2.
[44] Ibid., 6.

> portability of operating systems to legitimate standards with open interface definitions.[45]

The result of these demands for openness was manifested in what Kelty describes as the emergence of a 'new moral-technical order' that is epitomized in FOSS. Moreover, Kelty shows how under the calm sea of a general desire of an ambiguous kind of openness, there were undercurrents that could not be reconciled and tensions between incompatible moral-technical orders:

> On the one hand the promise of multiple manufacturers and corporations creating interoperable components and selling them in an open, heterogeneous market; on the other, an intellectual property system that promoted and required both secrecy and jealous guarding of source code, designs and ideas in order to differentiate products and promote competition. The tension proved irresolvable: without shared source code, for instance, interoperable operating systems are impossible. Without interoperable operating systems, inter-networking and portable applications are impossible. Without portable applications that can run on any system, open markets are impossible. Without open markets, monopoly power reigns. The failures and the successes of openness—the conflict between different moral-technical orders—are an essential component of the contemporary practice and power of Free Software.[46]

Accordingly, Kelty reads FOSS as an attempt to establish a 'self-leveling' playing field, or in other words, an attempt by a 'recursive public' to engage with, maintain and modify the infrastructure that allows it to exist as part of a political process. Kelty offers a detailed historical analysis of the rise of free software, looking at the practices of code sharing, the innovative use of copyright law, definitions of openness and the problems of coordination that arise in the absence of clear hierarchy. In an attempt to reflect on the cultural significance of open systems, Kelty ends the work by looking at

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[45] Ibid., 166.
[46] Ibid., 159.

several contemporary systems that build on FOSS and modulate it, particularly in the area of media and education resource sharing.

As stated, Kelty's earlier articles[47] are perhaps the closest scholarly engagement within the social science literature to the themes that are central to my own work. Generally, I found his empirical material rich and the analytical concepts and arguments compelling. Moreover, Kelty's choice of open systems as a unit of analysis resonates with my own desire to scope out these systems while facing the same challenge of outlining similarities without being able to show causal and/or historical continuities. However, where I am interested in the relationship of open systems with the closed system that surround them, Kelty, writing in the cultural anthropology tradition, is mainly interested in the internal structures, and where I'm interested in practices, policy and political implications, Kelty is interested in cultural significance. Nonetheless, Kelty's work and my own complement each other in interesting ways, and I use his concepts in several of the chapters that follow. The ARRL is a good historical example of a recursive public, and my version of the history of FOSS also sheds light on the ways in which geeks and hackers try to control the infrastructures of their communities, in line with Kelty's theory. Where our works diverge empirically is in case studies like ARRL, BIOS and the GOC that veer off from Internet related IT while trying to show similarities. Our works diverge theoretically in my attempt to engage not only with what modes, structures, and practices of coordination, but also with those of participation, collaboration, sharing, and distribution. At the same time, Kelty's theory is primarily a cultural theory from within a cultural-anthropological tradition while mine is an attempt to enhance S&TS.

[47] See Christopher M. Kelty, "Hau to Do Things with Words," *Knowledge and Society* 13 (2001).

Gabriella Coleman – FOSS and the liberal tradition

Gabriella Coleman's Ph.D. dissertation is by far the deepest and most comprehensive ethnographic study of a FOSS community to date. Coleman lived among hackers from the San Francisco bay area Debian Linux community for several years, and influenced directly by Kelty, who was one of her advisers, relying on interviews, participant observation and participation in numerous FOSS events, Coleman offers a rich account of the making of hackers, hacker communities, and free software. The bulk of the dissertation examines the vast array of practices hackers engage in, from participation in conferences to coding, debugging, and fighting over legal language on mailing lists. Together these practices contribute to the stabilization of a set of liberal values among FOSS developers.[48] In the early chapters of the work, Coleman outlines the history of FOSS and finds that it contains an unexpected, and sometimes surprising if not accidental combination of politics and technology. She writes:

> This history includes Stallman's creation of the FSF [Free Software Foundation] and copyleft (an overt act of political resistance); Linus Torvalds's pursuit of a hobby that actively sought contributions and quickly came to be the model by which other geeks initiated similar endeavors; the rise of new technologies (such as the PC and the Internet) that allowed for the domestic production of technology; and the raw energy that followed the festive bewilderment, the surprise recognition that quality software could be coded in collaboration with strangers over vast distances with the right technological, legal and human conditions.[49]

In the second part of the work, Coleman develops her main argument, which has two parts to it. First, she argues that hackers are foremost guided by a cultural desire for unencumbered "productive freedom." She explores what this desire means

[48] Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition", 422.
[49] Ibid., 420.

for personhood and subjectivity, and explains why Millian notions of liberty are attractive to hackers, and how over time they shape what becomes a 'geek public sphere'.[50] Second, she argues that while FOSS is centered on a technical practice of collaboration and sharing, FOSS's real innovation is in the legal sphere where it makes innovative use of copyright law.[51] Coleman calls attention to the idea that hackers challenge one sacred realm of liberal jurisprudence—intellectual property—by reformulating ideals from another one—free speech. She thus interprets FOSS as a liberal critique from within the liberal tradition, a critique that challenges the central role that property, and intellectual property play within modern liberalism. She writes:

> Without question, FOSS hackers are deeply entangled in a broader liberal debate that is intimately tethered to current historical conditions but that nonetheless speaks to a long history of contention over the definitions of individualism and freedom within liberal ideology. Probably more than any other current site of labor, FOSS production makes legible the current frictions between free speech and intellectual property regulations that have grown so markedly pronounced, in part because both sets of rights have undergone significant expansions in recent times. If courts have altered the provisions of IP law so as to sanction the conversion of knowledge into private property, they have also altered the definition of free speech laws so as to accord new protections to categories of expression such as political speech and, in some instances, source code.[52]

But while FOSS hackers are deeply entangled in these debates, only a minority among them chose to define their activities as overtly political. The majority of the hackers Coleman interacted with felt on safer grounds when accepting free software and notions of openness based on their technical merits and their catering of personal—not political—freedom. Coleman argues that this tension between FOSS as

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[50] Ibid., Ch. 5.
[51] Ibid., 3.
[52] Ibid., 424.

a socio-technical movement with political aspirations and FOSS as a set of community practices that cater to enhanced individual freedom helps explain many of the inherent contradictions in this phenomenon.

In my work I build on Coleman's findings in my discussion of structures of participation in FOSS projects, and I continue her argument about the tensions that exist in the various interpretations of freedom, when I discuss the morphing of free software into open source. Moreover, I extend Kelty's discussion of 'geeks' and Coleman's discussion of the 'hacker' sphere, and make the connection with the more general concept of hobbyists and amateurs. I also look at the tensions between the different interpretations of freedom in spheres beyond software and the connections of these tensions with the law.

Legal writing on free and open culture

In recent years, in an attempt to influence the way that new technologies will be used and regulated, several legal scholars have written extensively on the transitions brought about by new information technologies. Larry Lessig developed a model that focuses on analyzing the interplay between norms, law, markets, and code as a way of making sense of the battles between what he calls 'free culture' vis-à-vis 'permission culture,'[53] a division that grossly maps onto some dimensions of what I call here open and closed systems. Lessig argues that norms, law, markets, and code constitute regulatory regimes that influence the behavior and freedoms of individuals within a given society, and that together they set the constraints and limitations on what one can or cannot do. They are all forms of regulation on human practices, which determine how individuals, groups, organizations, communities or states regulate and

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[53] Lawrence Lessig, *Code and Other Laws of Cyberspace* (New York, NY: Basic Books, 1999), Lawrence Lessig, *Free Culture : How Big Media Uses Technology and the Law to Lock Down Culture and Control Creativity* (New York: Penguin Press, 2004), Lawrence Lessig, *The Future of Ideas : The Fate of the Commons in a Connected World*, 1st ed. (New York: Random House, 2001).

are regulated. Lessig argues that it is essential for us to consider these four forms of regulation as they pertain to one another because they interact and can compete and that each of these concepts can reinforce or undermine another. Lessig further describes in detail how power nexuses such as, for example, the movie industry, use their control to influence a combination of these categories in order to fortify their long-standing interests. I build here on Lessig's model, expanding it by paying special attention to the power of users to interpret technologies and their use in ever-new contexts. Users' interpretations are not things that can be read formally into the system in advance. User practices in the form of local resistance, much before they stabilize into norms can be significant drivers that influence the stabilization of a technology. As Kilker argued, and as the cases below will show, norms, laws, markets and codes are often in flux in the early days of a technology and will further change as users evolve new practices and the systems designers and operators respond to users. In this way, I will show how each of these regulatory regimes is in and of itself prone to social construction and cannot be treated as a fixed term.

Yochai Benkler – Peer Production

In his influential article *Coase's Penguin,*[54] and later book *The Wealth of Networks,*[55] Yochai Benkler argues that the industrial information economy of the mid-nineteenth and twentieth centuries is now being displaced by a "networked information economy" and that this transition has profound implications for the way in which information, knowledge, and information-rich goods are produced, exchanged, and used. Benkler's theory is primarily an economic observation that suggests that the "networked information economy" is centered on a new mode of production that he

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[54] Yochai Benkler, "Coase's Penguin, or Linux and the Nature of the Firm," *Yale Law Journal* 112 (2002).

[55] Benkler, *The Wealth of Networks : How Social Production Transforms Markets and Freedom*.

calls 'social production' or 'peer-production', characterized as production that is based on non-market, non-hierarchical, non-proprietary principles. This reflection is divided into four major points:[56]

1. Proprietary strategies are not as dominant in the information production system as previously believed. Analysis of empirical data shows that major information-sectors, like education, for example, are not based on proprietary, profit-seeking strategies but rather on other strategies, such as government funding.
2. Intellectual property rights, which grant limited monopolies and underwrite many market transactions, can be seen as a form of tax on nonproprietary models of production in favor of the proprietary models. By granting protections such as patents and copyrights the cost of inputs for the nonproprietary models rises.
3. The rapid development and declining costs of new technologies of information processing, storage, and communication have made nonproprietary models more attractive and effective than was ever before possible. In other words, basic technologies have made social reciprocity, redistribution, and sharing possible on a larger scale than ever before. The result is that the means of production of information, knowledge and culture are now distributed among many individuals who are thus, to a greater extent than before, freed from the need to cater to the mass market or to heed to the control of state bureaucracies.
4. Peer production is a rising mode of production that is typified by a cluster of phenomena, from free and open-source software to newsgathering and

[56] Ibid., pp. 460-463.

> encyclopedia authoring. Peer-production presents a stark challenge to conventional thinking about the economics of information production, and can be overlooked, but it is there nonetheless.

Throughout the book Benkler argues that, to a much larger degree than previously believed, the networked information economy is characterized by decentralized individual action carried out through distributed, non-market means that do not depend on market strategies or on strong intellectual property rights. What characterizes this networked economy, he argues, is:

> …that decentralized individual action - specifically, new and important cooperative and coordinate action carried out through radically distributed, nonmarket mechanisms that do not depend on proprietary strategies - plays a much greater role than it did, or could have, in the industrial information economy. The catalyst for this change is the happenstance of the fabrication technology of computation, and its ripple effects throughout the technologies of communication and storage…The core distinguishing feature of communications, information, and cultural production since the mid-nineteenth century was that effective communication spanning the ever-larger societies and geographies that came to make up the relevant political and economic units of the day required ever-larger investments of physical capital. Large-circulation mechanical presses, the telegraph system, powerful radio and later television transmitters, cable and satellite, and the mainframe computer became necessary to make information and communicate it on scales that went beyond the very local. Wanting to communicate with others was not a sufficient condition to being able to do so. As a result, information and cultural production took on, over the course of this period, a more industrial model than the economics of information itself would have required. The rise of the networked, computer-mediated communications environment has changed this basic fact. The material requirements for effective information production and communication are now owned by numbers of individuals several orders of magnitude larger than the number of owners of the basic means of information production and exchange a mere two decades ago."[57]

[57] Ibid., 3.

The quintessential example for this shift, he argues, is FOSS,[58] where distributed groups of volunteers are able to outperform major industrial players, but it is apparent also in the creation of music, entertainment, news, encyclopedias and other forms of information, knowledge and culture. The bulk of Benkler's work provides a framework that explains how peer-production is both efficient and sustainable, and how social production holds great promise for freedom, justice and human development. The distribution of the means of production, he argues, coupled with the new modes of cooperation gives users more power, which in turn creates more opportunities for democratic participation, lowers costs for developing countries, and democratizes the creation of our culture.

My concept of 'open systems' does not map directly on systems that use peer-production as their central mode, but there are direct correlations between these concepts. I accept most of Benkler's economic insights and units of analysis, however, the approach I take here is different. Whereas Benkler focuses on production, labor relationship and economic units of analysis, I focus on meaning making processes, identity-building, and rhetorical strategies as the prime elements in the stabilization of a technology. This difference in approaches also marks my attitude towards other economic studies of open systems (see discussion about Weber, David, Ghosh below and other sources in Chapter 3). While Benkler and the economists focus primarily on understanding the economic aspects of these systems, my analysis focuses on the social layers within which these economic actors operate. To this extent I both accept their explanations and models and find it lacking. I think that economic explanation of open systems can be at one and the same time useful and superficial. They are useful to the degree that they can explain (or even predicts) the behavior of rational actors in

[58] Ibid., pp. 5, 63-67, 436-437.

these systems. But they are superficial when they try to model everything within pure economic terms. It's hard to believe that an economic model can accurately capture the 'returns' associated with an actor's joy of learning a new technology, or the feelings associated with building one's identity within a group of socially significant others. The economic models also do not properly address the fact that the social, legal, and technical orders associated with these systems are themselves changing. (See the discussion on Weber below.)

Beyond our different attitude towards economics, there are further differences between my work and Benkler's. Whereas Benkler sees peer-production primarily in economic terms enabled by law, I see the transition as a nexus of social, economic, and legal negotiations between social groups. Whereas Benkler sees the rise of the Internet and cheap networking technologies as a shift in 'code' that underwrites much of the impending 'revolution', I see the Internet's affordances (a terms I better define in Chapter 4) as being socially constructed themselves. Whereas Benkler sees this entire shift happening towards the end of the twentieth century, as I will demonstrate, these shifts have been brewing for decades, if not centuries.

Janet Hope - Open source biotechnology

There aren't many works that investigated the open source model outside the realm of software, and even fewer within legal writing. One scholar that did look at these issues is Janet Hope, who wrote her doctoral dissertation on open source biotechnology.[59] Directly influenced by Benkler, and guided by Peter Drahos, Hope investigates the theoretical applicability and policy imperatives of the open source model to biotechnology. In her interpretation, free and open source software developed as a response to restrictive copyright practices in the early 1980s, in an

[59] Hope, "Open Source Biotechnology". The dissertation is due to be published in 2008 by Harvard University Press under the title 'BioBazaar'.

attempt to reconcile the conflicting public interest of broad access to software and the developers' profit seeking motivation. Faced with the dramatic expansion of intellectual property rights protections in the areas relating to biotechnology, Hope investigates the potential of a parallel move towards open models in the life sciences. She argues that open source biotechnology is both desirable from a policy perspective, and is quite feasible as the elements necessary for it already exist.

In approaching the subject Hope relies on a theory of scientific exchange developed by Stephen Hilgartner and Sherry Brandt-Rauf called the Data-Stream model.[60] According to this model, the way that data is exchanged and transacted upon is consequential to the way scientific knowledge is being built, and hence the law has direct influence over the ways in which such data is shared, protected, transported, etc. Following Hilgartner's lead,[61] Hope tries to understand how researchers employ legal mechanisms for controlling data access, in face of the tension between the law's reductionist approach to ownership, on one hand, and the continuity of data streams and research networks on the other hand. She is particularly interested in the bearings of this model on the area of intellectual property rights (IPR). She finds that:

> The commercialisation of biotechnology research and development from the mid-1970s to the present has triggered widespread concern that privatisation of scientific knowledge under an increasingly strong intellectual property protection regime could hinder the progress of science by taking the tools needed for further innovation out of scientists' hands… Hilgartner 's data stream analysis shows science as a complex decentred [sic] system of bargaining and gift relationships in which there is a variety of incentives for researchers to transfer uncodified knowledge. The explanation, applicable in both "pure" science and technology settings, is that innovation proceeds most efficiently by way of independent initiatives on the part of many

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60 S. Hilgartner, "Data Access Policy in Genome Research," in *Private Science*, ed. A. Thackray, *The Chemical Sciences in Society* (Philadelphia: University of Pennsylvania Press, 1998).
61 S. Hilgartner, "Access to Data and Intellectual Property: Scientific Exchange in Genome Research," in *Intellectual Property Rights and Research Tools in Molecular Biology*, ed. N. R. Council (Washington, D. C.: National Academy Press, 1997).

> different actors linked in a way that facilitates communication and provides incentives for individuals to signal the possession of new information. Intellectual property rights may or may not be useful in promoting the exchange of innovation-related information in other contexts, but could actually be harmful in biotechnology research and development, where much information is highly "uncodified" and information flow is particularly important.[62]

From this Hope concludes that an open model for biotechnology that does not rely on strong intellectual property protections but, rather, on alternative mechanisms for knowledge sharing, might be better suited for biotechnological research, and that whether indeed that's the case, is an empirical question whose answer depends on the transaction costs associated with each mechanism. She proceeds to look at empirical data and finds that indeed in both biomedical biotech and agricultural biotech, strong IPR raise the transaction costs in ways that could be avoided by adopting a more open model. She concludes:

> The ability to conduct [biotechnological] research and development depends on access to a full set of enabling technologies, analogous to the basic toolkits needed for cooking, gardening, sewing or any of a thousand other familiar productive activities. The fact that the elements of these toolkits are protected by intellectual property rights instead of being available in the public domain has two consequences… First, intellectual property protection means that putting a toolkit together requires more resources, not only because of the need to provide owners of individual tools with some return in exchange for granting access, but more fundamentally because the very fact that the tools are owned gives rise to search, negotiation and enforcement costs that would not otherwise exist.…The second major consequence of granting intellectual property rights in elements of the basic biotechnology toolkit is reduced competition at the next stage of development as tool owners impose reach-through conditions on the products of research and development conducted using their tools.[63]

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[62] Hope, "Open Source Biotechnology", 32-3.
[63] Ibid., 62.

What Hope suggests is that the way to lower the transaction costs and to advance biotechnology is to create a basic 'biotech toolkit' that will take direct inspiration from the open source model in software. Having such an open toolkit, she argues, will enable biotechnological researchers to gain access to cheap and accessible foundations, and focus their resources on innovation, increasing the overall value of biotech to society. Moreover, she projects that a combination of structural changes and the development of such a toolkit can create economic conditions that will allow industry participants to adopt the open source model of biotechnology for their own business interests.[64]

Hope's work offers a the most comprehensive review of the issues that surround open source biotechnology, and in that sense my work builds on her work directly. However, she is primarily concerned with theoretical arguments, and her review of empirical data is cursory. Many of her arguments are forward looking statements that make policy recommendations based on scarce evidence. In my review of BIOS (Chapter 6), I aim to make the connections between software and biology much more explicit, based on the detailed understanding of the actors who interpret these connections as such. I also ground my work with some specific examples of technologies that could be part of open biotechnological toolkit, which after the actors convention, I call the biotechnological 'stack'.

Legal perspectives – some additional works

Several other legal scholars like Pamela Samuelson and James Boyle have illuminated the intersection between the law, society, and new ICTs.[65] Their writings

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[64] Ibid., 225.

[65] Boyle shows how information --whether genetic, cultural, or commercial-- is tantamount to power, and questions about who owns it, who controls it, and who gets to use it become part of an information policy that can be influenced. Samuelson questions the adequacy and applicability of existing laws to activities occurring via new communications media such as the Internet and asks whether completely new laws are needed to deal with the Internet and other information technology developments, or whether existing laws should be adapted, and if so, in what ways. See James Boyle, *Shamans, Software,*

too include ideas that are fundamental to my work, primarily (1) the notion that information, in its broadest sense, is not just a commodity but also an essential input to innovation, knowledge creation, education, and social and political discourse; and (2) the notion that information policy is something that every citizen of the information society should care about. Information is also, and importantly so, an essential input to individuals' sovereign identity creation process as part of what Jack Balkin calls "democratic culture."[66] Balkin argues that democracy should be understood not only as a principle for decision making via majority voting, but also a regime in which each citizen has a say in defining 'who they are'. A democratic culture, Balkin argues, is a culture in which individuals have a fair opportunity to participate in the forms of meaning-making that constitute them as individuals. Democratic culture is about individual liberty as well as collective self-governance. Democracy is enhanced or diminished by the level to which individuals can participate in the production and distribution of culture and participate in the social negotiations that make them parts of such a culture. Moreover, Balkin argues that what unites the concepts of culture, personhood and historical existence is nothing less than the possession of certain cultural know-how.[67] Justice and democracy, thus, demand that individuals get maximal opportunities to attain and use this know-how. Clearly, information policy of the flavors Boyle, Samuelson, and Balkin wish to promote, is tightly linked with technological regimes. Open systems speak to the heart of the abilities of participation in information transmission and dissemination and by doing so depart from closed

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and Spleens : Law and the Construction of the Information Society (Cambridge, Mass.: Harvard University Press, 1996), Pamela Samuelson, "Five Challenges for Regulating the Global Information Society," in *Regulating the Global Information Society*, ed. Chris Marsden (New York, NY: Routledge, 2000).

[66] Jack M. Balkin, "Digital Speech and Democratic Culture: A Theory of Freedom of Expression for the Information Society," *NYU Law Review* 79, no. 1 (2004).

[67] Jack M. Balkin, *Cultural Software : A Theory of Ideology* (New Haven, CT ; London: Yale University Press, 1998), ix.

models. My proposed contribution to this literature is the S&TS notion that the very essence of 'information', what it is and the ways that it should be regulated, are in and of themselves social processes that are prone to social negotiations. I hope to add to several recent works on ICTs and regulation, by legal and non-legal scholars, which widen traditional legal writing when they try to combine ideas from critical and literary theory,[68] communication studies,[69] and science studies,[70] in order to discuss the interaction of technology and the law. In this work my aim is to extend these approaches by combining insights from social constructivism.

Economics of open systems

Steven Weber – The success of Open Source

Within the economics literature, Steven Weber's *The Success Of Open Source*[71] is the first book-size project that offers a comprehensive review of the open source phenomenon and its apparent economic success that seemingly defies traditional explanations. Weber argues that FOSS is not an exception to economic principles but, rather, the result of rational economic behavior of a community that is guided by standards, rules, decision-making procedures, and sanctioning mechanisms. The crux of Weber's argument is the claim that FOSS allows for a more economically

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[68] Julie Cohen, for example, uses the theories of Michel Foucault and Anthony Giddens to explain the extension of intellectual property enforcement into private spaces and throughout communications networks as a species of disciplinary regime. See Julie E. Cohen, *Normal Discipline in the Age of Crisis* [Web] (Georgetown Public Law Research Paper No. 572486, August 4 2004 [cited 05/06 2006]); available from http://ssrn.com/abstract=572486.
[69] Tarleton Gillespie uses communication theory to explain how the regulation through law and code is slowly but surely gravitating towards ever-earlier stages of the technological innovation process. See Tarleton. Gillespie, *Wired Shut: Copyright and the Shape of Digital Culture* (Cambridge, MA: MIT Press, 2007).
[70] Simon Cole offers a history of the criminal identification system to show that it is far less coherent than we have been led to believe. See Simon A. Cole, *Suspect Identities: A History of Fingerprinting and Criminal Identification* (Cambridge, MA: Harvard University Press, 2001).
[71] Weber, *The Success of Open Source*.

efficient process of innovation. In contrast to common neo-classical economic wisdom that suggests that innovation is driven by the promise of individual and corporate wealth and that, therefore, intellectual property protections are the best catalysts for innovation, Weber shows how dozens, hundreds, or thousands of independent programmers can create software in a more effective process by making unpaid contributions to organic projects that are governed by trial and error. In that sense, Weber finds that FOSS poses a puzzle to anyone interested in problems of coordination and division of labor,[72] and he aims to solve this puzzle from the perspective of political economy. Within that framework the key question to be answered is that of collective action and motivation. Weber writes:

> The elementary political economy question about open source software is simple. Why would any person choose to contribute—voluntarily—to a public good that she can partake of, unchecked, as a free rider on the effort of others? Because every individual can see that not only her own incentives but the incentives of other individuals are thus aligned, the system ought to unravel backward so no one makes substantial contributions, and the good never comes to be in the first place.[73]

In addition to the motivation question, to an economist FOSS raises some fundamental questions about the limits of coordination and complexity. In traditional production systems, either hierarchy or the market system governs coordination, but FOSS uses neither of these. So how does it work? Weber notes that particular questions arise about complexity management. According to a famous observation made by Frederick Brooks and known as Brooks's Law[74] adding manpower to a complex software project cannot accelerate it. The reason is that additional programmers can only extend the work capacity linearly while the complexity of the overall project grows geometrically

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[72] Ibid. p. 2
[73] Ibid. p. 9
[74] Frederick P. Brooks, *The Mythical Man Month: Essays on Software Engineering* (Addison-Wesley Pub Co, 1974).

because potential communication channels are increased dramatically. FOSS projects seem to escape this fate, and can grow to become thousands of members strong. How can they do it, in violation of Brooks's law? The answer to these questions, Weber argues, can be sought by understanding open source projects as processes of production. Understanding them as such explains how they abide by very strict social norms, business models, and an economic logic that fall squarely within the realm of what is predictable in traditional economics and grounded in both micro foundations and macro organization.[75]

For microfoundations, Weber looks at surveys of open source developers to understand why individuals, as individuals, participate in open source projects.[76] He summarizes the findings and groups them into six distinct categories:[77]

(1) Art and beauty. Some programmers find in software an aesthetic value. For them writing software out in the open is a chance to exhibit these values and share them with their peers. Developers often talk about 'clean' code and 'elegant' solutions.

(2) Job as vocation. Some get paid to do it. In recent years there have been a slew of companies that for various reasons support open source, and hire programmers to develop open source projects. Others do not get paid directly to write open source, but contribute code that they otherwise wrote already for some paid-for project.

(3) Joint enemy. Some do it because they want to fight the proprietary software companies that they perceive as evil. Microsoft usually plays the arch-enemy's role, and the desire to see Bill Gate's empire collapse is sufficient motivation for some.

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[75] Weber, *The Success of Open Source*, 56-57,Ch. 5,6.

[76] See below the discussion on the source material from Paul David and Rishab Ghosh, which is a major source for Weber.

[77] Weber, *The Success of Open Source*, 135-45.

(4) Ego boosting. Some choose open source intending to set themselves up with intellectual and creative challenges. Open source projects give these developers a chance at self-recognition and self satisfaction.

(5) Reputation. Some developers seek the reputational payoff, which can be expressed as either peer recognition within the community or better chances of getting jobs outside it. In these cases contribution to the open source project is a form of signaling mechanism that sends a signal to relevant peers about the prowess of the individual developer.

(6) Identity and belief system. Lastly, for some developers participation is a matter of moral principle that is tied directly to their perception of self and identity. For these hackers open source is a belief system that promotes values like information freedom that they strongly identify with.

In sum, Weber writes:

> Adding together these elements of individual motivations yields a pretty compelling story about why some individuals, under at least some conditions, would contribute time and energy towards writing code for open source software. If you now say that the extremely low transaction cost environment of the Internet allows these people to find each other easily through a soft version of the law of large numbers, you might be tempted to accept the notion that individual motivations are all you need to explain the outcome…[78]

But as Weber notes, microfoundations are often not sufficient to explain a complex system like open source. The politics of the phenomenon need to be explored, as well as the ways in which these diversely motivated individuals actually cooperate in order to produce something together. To answer these last questions Weber makes some general observations about the projects' macro-organization principles and finds that there is no overarching organizational template but, rather,

[78] Ibid, p. 146

each open source project can be seen as an 'experimental' combination of norms, formal and informal governance mechanisms, coordination mechanisms, and licenses. The shared principle among these 'experiments' is that they are all self-conscious attempts at error correcting mechanisms that keep the system intact and try to float the bugs as efficiently as possible.[79] Overall, Weber argues, these mechanisms are very successful in achieving their goal of allowing large groups of developers to cooperate in the development of very complex software.

Weber argues that of all the organizational principles software licenses play a key role as they embed in them the social contract that helps glue the community together. Of all open source licenses, the GNU (General Public License) is the most dominant one, and its language speaks strongly to the spirit of the free and open source software projects it aims to regulate. Weber discusses this license at length, and notes that the GPL embodies three explicit principles –freedom, non-discrimination, and pragmatism-- and one implicit principle—meritocracy—that together are the core of what a developer can expect when joining and open source community. As Weber notes, there are great variations within licensing terms, and those in themselves often cause debates within the community.

To summarize, Weber book offers a high-level overview of the open source phenomenon, but it suffers greatly from a limited approach and lack of primary material. While Weber's economic insights and his use of terms from political economy are an important step in giving a comprehensive explanation to FOSS, he mainly sees FOSS in strict economic terms: he talks about efficiency, competition within a market, and industry sectors. He defines his book as "a book about technology and society" but he means it in the deterministic sense that "changes in

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[79] Ibid, p. 189

technology uncover hidden assumptions of inevitability in production systems and the social arrangements that accompany them."[80] What is more, he believes that FOSS can be wholly contained within traditional economic thinking. He goes on to write: "an uneconomic explanation of open source, if such a thing really were possible, would probably be uninteresting and also probably wrong. The challenge is to add substantive meaning to a rational and economic understanding of why the relevant individuals do what they do, and how they collaborate, in open source."[81] In the following chapters I try to accomplish exactly that; it will be up to the reader to decide if my work is either boring or wrong, I hope it is neither.

Ghosh and David - Empirical studies of the economics of open source

In both law and economics several theories have been proposed to explain open source, but most of these rely on anecdotal evidence or on primary evidence found elsewhere. There have been fewer attempts at quantitative open source research, in part because many open source communities, being highly dispersed, are hard to quantify. The most comprehensive source of empirical data is a set of surveys and a meticulous review of software code carried out by Rishab Ghosh from the Maastricht Economic and Social Research and Training Centre on Innovation and Technology and Paul. A. David from Stanford's Center for Economic Policy Research (SIEPR).[82] The surveys queried thousands of FOSS developers around the world, asking them for their motivation, levels of participation and work habits. They also analyzed the

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[80] Ibid, p. 2

[81] Ibid, p. 226

[82] Paul A. David, "From Keeping "Nature's Secrets" to the Institutionalization of "Open Science"," in *Code: Collaborative Ownership and the Digital Economy*, ed. Rishab Aiyer Ghosh (Cambridge, MA: MIT Press, 2005), Ghosh, *Free/Libre and Open Source Software: Survey and Study* ([cited 12/04/08]), Rishab Aiyer Ghosh, "Understanding Free Software Developers: Findings from the Floss Study," in *Making Sense of the Bazaar: Perspectives on Open Source and Free Software*, ed. J. Feller, et al. (Sebastol, CA: O'Reilly & Associates, 2003), Rishab Aiyer Ghosh, "Why Collaboration Is Important (Again)," in *Code: Collaborative Ownership and the Digital Economy*, ed. Rishab Aiyer Ghosh (Cambridge, MA: MIT Press, 2005), Rishab Aiyer Ghosh, ed., *Code : Collaborative Ownership and the Digital Economy* (Cambrdige, MA: MIT Press, 2005).

source code and source control systems of several leading open source projects, primarily the Linux kernel, in order to quantify the participants' particular contribution to a project.[83] The result is a glimpse into the open source world that gives a good overview of the composition of the open source contributor demographics and motivations. The Stanford team concluded that (quote):

- OS/FS [open source/free software] developers tend to be highly educated and employed, with ambitions of advancing their careers in the future.

- Contributing to the community of developers, promoting the OS/FS movement, and improving software's functionality all frequently motivated respondents to start developing OS/FS. OS/FS developers tend to believe OS/FS development can supplant much of proprietary development.

- Approximately 1⁄2 of developers have earned money through their work on OS/FS. Support for OS/FS projects from external businesses and organizations has increased significantly since a decade ago. Now [2003], more than half of developers have worked on externally supported projects.

- Approximately 1⁄2 of developers launched their projects and are the "project maintainer" for their current project.

- Most respondents support OS/FS licenses as means of protecting software users' general freedom and ensuring that credit is given for their work.

- Developers have contributed to an average of 5.5 projects, but most projects have very few contributors (median 6).[84]

The European survey found that (quote):

- Almost all (98.8%) of respondents to the FLOSS developer survey are male.[85]

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[83] In open source projects each contribution is attributed to a particular author in a way that is traceable by analyzing the logs of an inherent version control system. See the discussion in Chapter 3.
[84] David, Waterman, and Arora, *Floss-Us - the Free/Libre/Open Source Software Survey for 2003* ([cited 12/04/08]).

- Developers are quite young, with over 60% between the ages of 16 and 25.
- 55.7% of all developers classified their relationship with the community as "I take more than I give" and a further 14.6% felt their contribution and reward was balanced; only 9% could be classed as consciously altruistic in that they reported that they give more than take.
- 53.2 of respondents had social motivations, 31.4% had career/monetary concerns, 12.7 had political motivations, and 2.6 had software related motivations.[86]

The picture that emerges from these empirical studies is surprising. In contrast to conceptions, like Eric Raymond's, of the open source world as a gift economy[87] it turns out that it's a young, educated, male-dominated sphere, in which over half the participants work for money and not for fame, and do it for their own good rather that the good of the community. What is also surprising is the amount of commercialization of open source software and the level at which commercial interests permeate this world.

These studies are well designed and are very extensive in scope and methodology, and I rely on them as a qualified source of both data and insights. The studies do not cover anything outside the world of software, and also do not have any longitudinal aspect, assessing the shifts over time. The four case studies I investigate in my work offer interesting contrast to Ghosh's and David's work, as I try to understand the inner workings of communities that are different in composition and motivation from that of the open source world. Repeating Ghosh and David's surveys

[85] The authors recognize that there might be a slight under-representation of women due to methodology, but clearly there are very few women participants.
[86] Ghosh, "Understanding Free Software Developers: Findings from the Floss Study," 11-14.
[87] Eric S. Raymond, *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*, 1st ed. (Sebastopol, CA: O'Reilly & Associates, 1999).

in the area of biological open source could be an interesting future project, but it is beyond the scope of this work.

Summary

Having reviewed this literature, the following section outlines the gaps that my work aims to fill. These can be grouped into four areas:

(1) By and large, the S&TS literature is focused on ‘closed’ systems (in contrast to systems that are open to volunteer participation). Many of the social-historical studies concerning technological innovation and change expose --and define-- the inextricable association of science and technology with government-funding, for-profit corporations, and global markets.[88] Evidently, the ARRL, the GOC, Linux, and BiOS, like all other open systems, have been developed alongside better-known closed, proprietary systems like commercial long-distance communication networks, military radar technology, the Unix operating system, or patented technologies in the life sciences. Social constructivism offers a comprehensive framework for understanding the stabilization of technologies of the latter kind, and it is particularly good in explaining artifacts or small systems, but it is less suited for explaining how networks grow, prosper and stabilize. The existing literature is lacking theories and empirical studies of large-scale, participatory, volunteer-based system. The anthropological literature, primarily Kelty, starts making these connections, but is focused on recent ICT systems, and thus looses the historical precedents.

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[88] To name just two prominent works, see: (1) Hughes, *Rescuing Prometheus : The Story of the Mammoth Projects--Sage, Icbm, Arpanet/Internet, and Boston's Central Artery/Tunnel--That Created New Style*. Hughes believes that between 1950 and 1970 the military/industrial/university complex played a far more innovative and beneficial role than is generally acknowledged. In fact, in his introduction he likens America’s technological transformations in that period to a “second creation”; (2) Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge, MA: MIT Press, 1993). MacKenzie explains how politics, technology, and economics come together in the U.S. multi-billion dollar missile guidance system’s development.

(2) Most scholarly accounts aimed at explaining 'open source' systems are focused on economic explanations and do not offer rich case studies and sufficient grounding in social theory. The legal and economic literatures offer more generalizable theories, but they tend to ignore the richness of the cases, and to a great degree they ignore the diverse set of communities, institutions, motivations, practices, social structures, and social interactions, focusing instead on their economic shadow. In my work I try to take a hybrid approach, looking at both the economic and social aspects of said systems.

(3) With the exception of Kelty's work, there have been few attempts in the social science literature to draw connections between software systems and systems in other domains that share similar social, technological and economic structures. A key contribution of my work will be in making these connections. As stated in the introduction, I am not proposing that 'open systems' is anything but an analytical concept, and yet I think that by looking at systems across domains and historical periods, and by explaining the continuities and discontinuities a rich understanding of how a growing class of systems operates can be gained.

(4) Most accounts of 'open source systems' focus on the last two decades of the twentieth century, and do not offer historical contrasts and connections where these are due. Kirsten Haring, for example, sees today's system as a direct continuation of the practices of radio hams. She writes:

> Whether serving as leaders or provocateurs, hobbyists demonstrated diverse options for technical culture. Hobbyists engaged with technology in a way that was fun, collaborative, educational, intense, and creative. These methods and values were independent from, and at times in direct conflict with, the technical culture of profit-driven production… A cooperative spirit persists today in open-source development, in the legitimate distribution of free software, and in cavalier attitudes toward the illegitimate copying of proprietary

> software. This spirit is a legacy of hobbyists and a reminder that there exist alternative ways of using and relating to technology.[89]

In what follows, I try to make some of those links more explicit. There is no causal chain between earlier forms of voluntarism to the systems I write about, and yet some of the legacy that Haring discusses persists across these domains.

As stated in the introduction, my work is situated within these gaps. It draws connections to all the works described above, as well as to many other works that will be cited throughout the dissertation. While it relies on each of these bodies of literature, it tries to push each of them in important directions. What follows in the next several chapters is my social-historical interpretation of open systems, which is based on an amalgamation of the aforementioned genres. My work tries to do several things in parallel: it situates large-scale participatory systems within a historical context; it places a new emphasis on units of analysis like 'community' and 'identity' that become significant in these systems; it emphasizes the important role of regulation in the stabilization of technology; and it looks at the ways in which these systems push the boundary of traditional economic models. Taken together, my hope is that through the detailed analysis I offer in the four case studies, the reader will be left with a generalizeable account of said systems that can be applied to many more systems in our time.

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[89] Haring, *Ham Radio's Technical Culture*, 17-18.

CHAPTER 3:

FREE AND OPEN SOURCE SOFTWARE – THE CODE MEETS THE LAW

> I think that to try to own knowledge, to try to control whether people are allowed to use it, or to try to stop other people from sharing it, is sabotage. It is an activity that benefits the person that does it at the cost of impoverishing all of society.
>
> Richard Stallman, founder of the Free Software Foundation[1]

> Software is like sex, it's better when it's free.
>
> Linus Torvalds, inventor of Linux, the free operating system[2]

Introduction

This chapter investigates the phenomena of free and open source software (FOSS), the poster child of the class of systems that this dissertation aims to explain. As both an analytical term and an actors' category, FOSS has several compounded meanings. It is a catch-all phrase for an assemblage of software applications, software development methodologies, software code, and legal instruments, which are at the heart of a mesh of advocacy organizations, developer communities, user groups, and, increasingly, commercial interests. In the main, FOSS revolves around communities of volunteers who write a wide variety of software applications and distribute them for free, together with their source code, and under permissive terms for re-distribution. What was a fringe interest within the software community in the mid 1980s has undoubtedly exploded since 1998. After two decades of impending change, FOSS's

[1] Richard M. Stallman, "Interview with Byte Magazine Editors David Betz and Jon Edwards," *Byte Magazine*, July 1986 1986.
[2] Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*, Back cover.

uptake in the software industry in general, and the Internet particularly, is hard to miss considering some of the following statistics:[3]

- Open source software applications like *Sendmail* and *BIND* are two of the most basic building blocks of the Internet and are used regularly by virtually all Internet users;
- Over 60% of Internet web sites rely on *Apache*, an open source web-server, and a quarter of the world's servers run *Linux*, the free operating systems;[4]
- An estimated 30,000,000 people worldwide use *Linux,* the free operating system, on their desktop computers in lieu of the rival, Microsoft's Windows™ and about the same number use Apple's Macintosh OS X which is based on an earlier free operating system called BSD;[5]
- 30% of all Internet users, an estimated 300 million people, browse the Internet using the popular open-source web-browser Firefox.[6]
- Over 100 million people have downloaded software from SourceForge.net, the world's largest FOSS repository that hosts over 20,000 software utilities, packages and applications.[7]

FOSS's organization of labor around communities and its practice of source code distribution stand in stark contrast to earlier practices of firm-based software production and for-profit black-boxing of software. Arguably, the rapid adoption of

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[3] Statistics are accurate for 2007.
[4] Apache, an open source web server is by far the leading web server in use, with a market share which is double of all the other technologies combined. See Netcraft, *Web Server Survey* [Web] (NetCraft, 2006 [cited December 18th 2006]); available from http://news.netcraft.com/.
[5] As of November 2006, there were 74.9% of Internet users were using Windows XP, 3.3% were using Linux on their desktop, and 3.5% were using MacOS. Combined, Mac and Linux are used by about 70,000,000 people. See *Browser Statistics Survey* [Web] (Refsens Data, November 2006 [cited December 15th 2006]); available from http://www.w3schools.com/browsers/browsers_stats.asp.
[6] Firefox is a descendant of Netscape's Navigator. See the section below on how and why Netscape released its code. As of November 2006, 59.9% of users used Microsoft's Internet Explorerer and 29.9% were using Mozilla's Firefox. See Ibid.([cited 12/04/08]).
[7] *Sourceforge.Net Software Map* [Web] (December 25th 2006 [cited December 20th 2006]); available from http://sourceforge.net/softwaremap/.

FOSS had been driven by freedoms that pertain to both liberty and economics. As I will argue, the rise of FOSS is underwritten by the dual meanings of the term 'free' in English. Free and open source software, for the most part, are both libre and gratis.

This chapter tells a story within a story. The main storyline follows GNU/Linux, a free computer operating system that was started by MIT hacker Richard Stallman in 1984 and became operational in 1991, after Linus Torvalds, a 20 year-old student at the time, added essential components to it. The case study tracks the development of GNU/Linux from 1984 to 2007 and explores how the work of Stallman and Torvalds and their early followers spawned a global community of hundreds of thousands of software programmers who explicitly aim to change the computer industry. The novelty in this story, that has been told several times before, but not within the S&TS literature, I will argue, is not the mere fact that a community of volunteers came together to write software. As I discussed in Chapter 2 when reviewing Atushi Akera's work, FOSS is clearly not the first attempt by computer users to share information and software. Motivation for cooperation had existed since the early days of computing, and, as I have noted, the 1955 SHARE user group is an early example of a collaborative effort aimed at collecting and sharing computer programs.[8] However, SHARE was based primarily on market-based motivations whereas, as I will argue below, today's FOSS operates based on a mixture of market and non-market motivations. For the early participants in SHARE, Akera argues, "a shortage of skilled programmers, high labor costs, and, most important, the inefficiency inherent in the fact that firms that had purchased an IBM mainframe still had to write their own programs to perform basic computing functions" were the key

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[8] Emerson W. Pugh, *Building Ibm: Shaping an Industry and Its Technology* (Cambridge, MA: MIT Press, 1995).. For a detailed history of SHARE see Akera, "Volunteerism and the Fruits of Collaboration: The Ibm User Group Share."

motivators.[9] In contrast to many actors in FOSS, SHARE's participants did not claim a moral high-ground. One of the things that this case study will show is how in FOSS actors that care about deep-rooted principles of information sharing cooperate well with those that are scratching personal itches, that want to make some money, or simply have fun. Moreover, as I argue below, FOSS is based on principles for the organization of labor that, on the face of it, depart significantly from precedents like SHARE. Ostensibly, instead of operating within a hierarchical, industrial order FOSS is completely open to volunteer participation and is best served by creating ad-hoc meritocracies. Taking issue with this claim will lead me to a second story that emerges within FOSS's canonical history.

In technology circles FOSS's reliance on volunteer power is commonly portrayed as 'revolutionary' technology, which is endowed with significant liberating power.[10] And indeed in the mid-1980s, the possibility of small, highly distributed groups of programmers to develop commercial-grade software shifted some power away from firms and towards communities of individuals. Recent developments, however, suggest that power might be shifting back into traditional structures. Today there are hundreds of thousands of FOSS developers worldwide who contribute on a regular basis to dozens of thousands of FOSS projects. While originally FOSS developers were all volunteers, in the last several years many of them began working for the world's largest computer companies. Corporations like IBM, Oracle and Sun Microsystems, to name just three, are turning to FOSS as a strategic choice, reorienting their businesses around it, hiring people to develop FOSS projects, and

[9] Akera, "Volunteerism and the Fruits of Collaboration: The Ibm User Group Share," 710.
[10] Tellingly, many of the books about FOSS, written from the technologists viewpoint, have some variation of the word 'revolution' or 'rebellion' in their title. See, for example, DiBona, Ockman, and Stone, *Open Sources Voices from the Open Source Revolution,* Moody, *The Rebel Code : The inside Story of Linux and the Open Source Revolution,* Raymond, *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary,* Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*.

investing huge amounts of money in FOSS. Recent research suggests that as many as 55% of FOSS developers code during worktime.[11] Clearly this process changes the meaning of FOSS and the ways that FOSS communities operate. Accordingly, there is a wide ideological schism between the two strands of FOSS. On one edge are advocates who emphasize the *freedoms* inherent in *free software*; on the other edge are advocates who emphasize its technological superiority and business advantages. The gap is widened by FOSS's accelerating commercialization. While Richard Stallman, the originator of the 'free software' movement perceived a need for acute social and political change in the face of a budding proprietary software industry, later actors turned 'free software' into 'open source' in order to adopt it to the needs of a market. This move, I will argue, attenuated free software's revolutionary potential and facilitated its appropriation by mainstream economic forces.[12]

The case study as a whole starts developing the framework that will help us explain the class of open systems, which arguably has certain common organizing principles. As I outlined earlier, the exploration will touch on three themes. At the empirical level, the case study will explain how, in the context of software, large groups of volunteers solve problems pertaining to collaboration, cooperation, coordination, sharing, distribution and participation. I will investigate who participates in FOSS and why, the typical structure of a FOSS community, the ways in which it regulates itself, and the economic logic that its members share. Throughout the case study, I will note the ways in which FOSS departs from earlier systems and the ways it

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[11] Not all of these developers are employed in a FOSS project. Many of them are working in a traditional software firm, but are developing F/OSS with the consent of their employers for work or non-work needs. See Karim R. Lakhani and Robert G. Wolf, "Why Hackers Do What They Do," in *Perspectives on Free and Open Source Software*, ed. Joseph Feller, et al. (Cambridge, Mass.: MIT Press, 2005).

[12] This point will be elaborated at length below. For a poignant discussion about this transition as a process of re-calibration and translation, see Biella Coleman and Mako Hill, "How Free Became Open and Everything Else under the Sun," *M/C: A Journal of Media and Culture* 7, no. 3 (2004).

relies on them exploring how large-scale collaborations blurs the lines between amateurism and professionalism. The chapter will try to answer these questions based on both primary and secondary materials. It revisits some earlier writings about FOSS and brings forward the views of key FOSS players as expressed in interviews I conducted with them over the last five years. Additional insights and perspectives are based on eight years of my own participation and participant observation in FOSS projects, conferences and communities. In addition, the case uses popular press coverage and corporate press releases to portray the interpretation of key events by relevant actors.

The second theme, from which this chapter derives its title, will attempt to expand the basic SCOT framework to better accommodate the system under investigation. Particularly, the chapter questions the notion of closure in the context of a system that is open to volunteer participation, and is thus prone to re-interpretation. The chapter ends with the third theme, the larger question of open systems' effect on 'democratic culture.' I will explore this question through an analysis of the modes of participation in FOSS. I will return to all three themes in the following chapters as well. This chapter sets the ground.

The genesis of free software

This story begins in the early 1970s when, after two decades of expensive mainframe computing, plummeting hardware prices ushered in the possibility of more personal computers and the computer industry started gravitating towards distributed computing systems.[13] Up until that period computers were expensive, programs were

[13] The social history of this period is detailed in several canonical works. See Paul E. Ceruzzi, *A History of Modern Computing* (Cambridge, Mass.: MIT Press, 1998), Chapters 7,8. A hacker version of that same period is given in Eric Raymond, "A Short History of Hackerdom," in *Open Sources: Voices from*

machine-specific and software wasn't really separate from hardware in either the institutional or technological sense. Most software, by default, was free. It wasn't really free, but its cost was amortized in the price that the hardware manufacturers like IBM or the Digital Equipment Corporation charged for setting up their wares; when customers leased a 'computer' they typically paid for a bundle of hardware, software, and set-up and maintenance services. Accordingly, as evidenced by the example of SHARE discussed in Chapter 2, in the eyes of computer manufactures like IBM, duplication and sharing of software could only enhance the hardware. By the early 1970s, however, this status quo was about to change. In academic research centers like MIT's AI lab, Stanford, and Berkeley, as well as in industrial research centers like AT&T's Bell labs and Xerox's PARC, people like Ken Thompson and Dennis Ritchie, who invented Unix in 1969, were starting to write portable software that would be less dependent on a specific machine and could use relatively cheap hardware in order support many processes and many users in parallel. In a parallel process, in the mid-1970s the prototypes of the first personal computers like the Altair, were developed, and those machines too needed software to run. Thus, the new paradigm of decentralized computing emerged with a new generation of software like Unix and, later, DOS and BASIC. What was special about these new operating systems was that, unlike earlier operating systems, they were not tied to a particular hardware configuration. They could run on a variety of computers, and for that reason they could be produced once, and run many times over.

Martin Campbell-Kelly offers a detailed history of this period that explains the transition of software from being a customized product to being mass-produced and

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the Computer Revolution, ed. Chris DiBona, Sam Ockman, and Mark Stone (Beijing: O'Reilly Associates, 1999).

mass-consumed.[14] Relying primarily on industry analysis, trade journals, and financial data available in the public domain, Campbell-Kelly explains the key transition by means of labor theory: the constant lack of programming talent, programmers low productivity, and high error rates in software, created a crisis in software. Something needed to be done, and the solution was to mass-produced software. Software turned from software-package, to software product.[15]

Important to this story, however, is the notion that something else changed in this transition. Decentralization and mass production of software created many possibilities for technical and institutional re-alignment of norms and practices. How should the development and distribution of computer code for the new generation of computers be managed? How tightly should the software be coupled with the hardware? Would customers be willing to pay for software when the historical knot between software and hardware was untied? Who should write code and who should be authorized to tinker with it? Was there a 'right' way to develop software?

The history of free software begins with these questions and with the story of Richard Stallman, then a student and by now one of the world's most famous hackers.[16] Stallman had a very specific set of answers to these questions that he soon evangelized, seeding a movement that over the next 30 years became what FOSS is today. In 1974, at the age of twenty-one, Stallman graduated with a physics degree from Harvard University, but instead of practicing physics he followed his interest in computers into the Massachusetts Institute of Technology's (MIT) artificial intelligence (AI) lab where he had been working as a staff programmer during the

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[14] Martin Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog a History of the Software Industry*, *History of Computing* (Cambridge, Mass.: MIT Press, 2003), Ch.3,4.
[15] Ibid, p. 96.
[16] Throughout this work we use the term hacker in its benevolent sense, and not as a derogatory. According to a common, recursive definition, a hacker becomes a hacker when other hackers refer to him/her as such. Hackers who consider themselves benevolent are contrasted to crackers, who are those that attempt to break into compute systems and act unlawfully.

previous three years.[17] While at MIT, Stallman worked on an early time-sharing system that allowed several users to share one central computer. The mid 1970s were a tumultuous time at the MIT AI lab, and it was in that period that Stallman developed many of the ideas that would later be the basis of the free software ethos. When the concepts of personal computers and personal workstations started to mature, a score of private firms were spun-off of various research centers in order to financially exploit the opportunities of the promising software market that was being created. Three such software firms had direct bearing on Stallman's work. First there was AT&T's Bell Labs, which developed the Unix operating system. Initially Unix came with its source code, but in 1979, ten years after its creation, AT&T announced that it would no longer make the source code of Unix available for academic purposes.[18] *Lisp Machines Incorporated* (LMI) and *Symbolics Corporation*, were two small start-ups that were trying to monetize on the work done at MIT by commercializing software. In their quest for profit, however, all three companies had violated what Stallman perceived as a longstanding principle of information sharing that was codified in MIT's hacker culture of which he was a proud member.[19] Instead of offering software as an auxiliary good to hardware, freely available for anyone to use, share and modify, the new breed of software companies produced 'secret' software that was distributed without its source code and was sold for a large profit. Moreover, both *Symbolics* and *LMI* hired away from the AI lab most of Stallman's peers.[20] Within a few short years,

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[17] Data for this and the following paragraphs is based on my discussions with Stallman, on his published biography that is available from Richard Stallman, *Richard Stallman Biography* [Web] (2006 [cited November 26th 2006]); available from http://www.stallman.org/#serious. Further source material and a discussion of these events is available in Richard Poynder, *Freeing the Code: Interview with Richard Stallman, Founder of the Free Software Movement* [Web] (March 21st 2006 [cited November 24th 2006]); available from http://poynder.blogspot.com/2006/03/interview-with-richard-stallman.html.
[18] Moody, *The Rebel Code : The inside Story of Linux and the Open Source Revolution*, Ch. 2,3.
[19] This culture is documented in Steven Levy, *Hackers : Heroes of the Computer Revolution* (New York, N.Y.: Dell Pub., 1994), 422.
[20] The history of this episode is available in Sam Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software* (Sebastol, CA: O'Reilly & Associates, 2002), Ch. 7.

the busy corridors of the AI lab became almost empty, and so was Stallman's life, he told me in an interview, recalling that period as one of the low points in his life. As more and more of his friends left, Stallman developed an extreme version of a hacker ethic. Faced with the possibility of 'selling out' and abandoning his principles, Stallman decided to instead 'stick it out' as a matter of moral principle.[21] He felt furious and dismayed by the commercialization process and by the ease in which the principles of knowledge sharing, which were predominant in his hacker environment, were compromised by license agreements and copy protections. Stallman didn't know what to do next and considered getting a job somewhere where he could once again interact with people, he recalls. He interviewed at a Boston hospital, but decided that a computer administration job was not for him. Instead he figured out a plan for revenge. He planned to start a war against *Symbolics* and *LMI* that would defeat them at their own game of writing software. The 'war period', he recalls, gave new meaning to his life. *Symbolics* and *LMI* were fighting with one another for market dominance and supplied the AI lab with the software they wrote in hopes that it would be adopted. Stallman used this to his advantage by reverse-engineering the versions that the companies sent to MIT for validation. Russ Noftsker, the president of *Symbolics* at the time, recalls: "we develop a program or an advancement to our operating system and make it work. [We give it to MIT] and then Stallman …reimplements it. He calls it reverse engineering. We call it theft of trade secrets."[22]

Clearly, this is one of the rifts that separates FOSS from proprietary software, open from closed. The main meaning that software had attained in the minds of young managers like Noftsker was as property that should be protected by legal and business means and for which rent should be sought. Stallman, in contrast, was concerned with

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[21] Stallman Interview, and Levy, *Hackers : Heroes of the Computer Revolution*, 422.
[22] Ibid., 426.

the idea of computer users' rights to use, study, copy, modify, and redistribute computer programs with as little restrictions as possible. In 1985, Stallman quit his job at MIT and started the *Free Software Foundation* (FSF), a non-profit organization dedicated to the promotion of free software. In using the word 'free' Stallman was refering to the users' freedom not to price. In an early manifesto he explains:

> The Free Software Foundation is dedicated to eliminating restrictions on copying, redistribution, understanding and modification of software. The word "free" in our name does not refer to price; it refers to freedom. First, the freedom to copy a program and redistribute it to your neighbors, so that they can use it as well as you. Second, the freedom to change a program, so that you can control it instead of it controlling you; for this, the source code must be made available to you. The Foundation works to give you these freedoms by developing free compatible replacements for proprietary software. Specifically, we are putting together a complete, integrated software system 'GNU' that is upward-compatible with Unix. When it is released, everyone will be permitted to copy it and distribute it to others; in addition, it will be distributed with source code, so you will be able to learn about operating systems by reading it, to port it to your own machine, to improve it, and to exchange the changes with others.[23]

Revealingly, as a name for his operating system Stallman chose the recursive acronym "GNU" which stands for "GNU's Not Unix." Stallman wanted his innovative system to be 'not-Unix' because Unix represented lost freedoms. Stallman understood, however, that his new operating software needed to rely on an existing user-base and that it would be greatly aided by using an existing system as scaffolding during the system-building phase. To gain these advantages GNU had to be designed to be fully compatible with some other operating system, and a natural, if ironic, choice was Unix itself.

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[23] Richard M. Stallman and Paull Rubin, *Gnu's Bulletin Vol. 1 No. 3* [online newsletter] (GNU Project - Free Software Foundation, June 1987 1987 [cited 05/04 2004]); available from http://www.gnu.org/bulletins/bull3.html.

As soon as Stallman felt he had a grasp on the technical issues involved in producing GNU, he started focusing on championing free software and free licensing as a form of social activism. This transition is not surprising when remembering that, at least in Stallman's mind, the main perceived problem was social and not technical. As Christopher Kelty argues in one of his early works, free software in its very nature was a critique of existing laws, contracts, and business practices, and it was designed to explicitly change the "political-economic structure of society."[24] In order to actualize this revolutionary potential, however, technology was not enough. The FSF needed to undermine the alternative interpretation of software as a form of (intellectual) property worthy of legal protection. Stallman came up with a legal trick that turned the copyright system against itself. [25] He invented the GNU General Public License (GPL), a new form of software license, as an alternative to traditional software licenses.[26] Unlike the public domain, that permits expropriation, GNU offered a mechanism for software programmers to use their copyrights in a way that would ensure that their software would always remain free. The way that it worked is that the original owner of the copyright stipulated within the agreement the things that he or she permitted a priori to users of their code to do, including to use it, study it, modify it, and distribute it, so long as any derivative work be distributed under the same terms and conditions. This method of software licensing became known as 'copylefting' because it turned the copyright system on its head. Copyleft uses copyright law not to conceal a program's source-code but rather to divulge it and encourage future

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[24] Kelty, "Hau to Do Things with Words," 3.
[25] In Stallman's terms, he 'hacked' the legal system. A 'hack' is an occasion in which a system is turned against itself. Hacks are not limited to software.
[26] The GPL was not created in one day, but over the period 1983-1989, based on Stallman's experiences in distributing EMACS, a text editor that he wrote and his fights with later developers how wrote subsequent versions which they distributed as non-free software. For a detailed history see Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software*, 122-26. See also Li-Cheng (Andy) Tai, *History of the Gpl* [Web] (July 4, 2001 2001 [cited November 15th 2006]); available from http://www.free-soft.org/gpl_history/.

modifications. Copylefting ensures that future users would retain both conceptual and legal flexibilities without needing to obtain any further license; future users' right to hack and tinker is ensured by the copyright law itself. Importantly, copyleftings is a legal cure to a perceived social problem and not simply a legal modification. As Stallman puts it:

> I'm trying to change the way people approach knowledge and information in general. I think that to try to own knowledge, to try to control whether people are allowed to use it, or to try to stop other people from sharing it, is sabotage. It is an activity that benefits the person that does it at the cost of impoverishing all of society. The principle of capitalism is the idea that people manage to make money by producing things and thereby are encouraged to do what is useful, automatically, so to speak. But that doesn't work when it comes to owning knowledge. They are encouraged to do not really what's useful, and what really is useful is not encouraged.[27]

In order to correct this situation the FSF chose to use the existing copyright law and create the GPL as a unilateral binding license agreement. Stallman describes the motivation and rationale behind the GPL:

> …if a program has an owner, this very much affects what it is, and what you can do with a copy if you buy one. The difference is not just a matter of money. The system of owners of software encourages software owners to produce something – but not what society really needs. [society] needs information that is truly available to its citizens… Society also needs freedom... and, above all, society needs to encourage the spirit of voluntary cooperation in its citizens."[28]

Note Stallman's choice of words. As I will demonstrate later, this language constituted part of the problem free software posed to the software establishment and was later challenged, and critically changed. However, in one of our early interviews, when I

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[27] Stallman, "Interview with Byte Magazine Editors David Betz and Jon Edwards."
[28] Richard M. Stallman, "Why Software Should Have No Owners," in *Free Software, Free Society: Selected Essays of Richard M. Stallman*, ed. Joshua Gay (Cambridge MA: Free Software Foundation, 2002).

probed him on the subject, Stallman strictly denied any socialist connection that some of his critics suggested:

> The idea that cooperation is an ethical imperative and that society should encourage it is much older than Marx—the world's major religions have been promoting these views for millennia. It makes no sense, therefore, to give Communism credit for them. It is usually enemies of the FSF that call them "communists," perhaps because they find it easier to criticize communism than FSF's actual views. This practice is known as 'red baiting.'[29]

Socialism aside, Stallman felt that no other group ever managed to build a fully functional free operating system. In his view, early attempts to build such a system amounted to mere distribution of disparate software applications. His, perception, though, was only partly accurate. Motivated by different reasons, several academic computer science research centers had made earlier attempts to distribute free operating systems complete with their source code. The most notable attempt was concentrated at Berkeley in the late 1970s. Forking[30] from early versions of AT&T's commercial versions of Unix, Berkeley's team released several versions of what came to be known as the 'Berkeley Software Distribution' or simply BSD.[31] For Berkeley's computer scientists, closed operating systems constituted a different problem than they did for Stallman. Berkeley's scientists were not interested in changing the way people treat information, rather, they wanted to maintain the level of cooperation that was standard for academic research while continuing practicing their cutting edge research on Unix, which AT&T was trying to commercialize. As one of the BSD team leaders

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[29] Richard M. Stallman, Interview, 04/15/2002 2002.

[30] A 'fork' in a software project is the occurrence by which the software development starts from one code tree and proceeds in more than one direction. I later explain how forking is in fact a shift in technological frames.

[31] M. K. McKusick, "Twenty Years of Berkeley Unix: From at&T-Owned to Freel Redistributable," in *Open Sources: Voices from the Computer Revolution*, ed. Chris DiBona, Sam Ockman, and Mark Stone (Beijing: O'Reilly Associates, 1999), 33.

explains, a key concern was the maintenance of a clearinghouse that could distribute software innovations to the respective community:

> With the commercialization of Unix, the researchers at Bell Laboratories [a subsidiary of AT&T] were no longer able to act as a clearing-house for the ongoing Unix research. As the research community continued to modify the Unix system, it found that it needed an organization that could produce research releases. Because of its early involvement in Unix and its history of releasing Unix-based tools, Berkeley quickly stepped into the role.[32]

Besides their desire to maintain a high degree of academic collaboration Berkeley's researchers had another problem with a closed and commercial version of Unix—it was too expensive. Up until the late 1980s, BSD was distributed with the source code on the condition that the receiver would first get (and pay for) a full license from AT&T. The cost of Unix was not an issue in the context of large research centers, but when networking developed, and it became feasible to connect cheaper machines to the network, the relative cost of AT&T's Unix licenses became prohibitive. Acting on this alarming signal, Berkeley went ahead and started a process of re-writing the parts of the BSD code that were inherited from AT&T. A decade later, after much work and litigation between AT&T and Berkley, BSD became a free operating system that was distributed under a short and permissive license called the BSD license, which granted users broad rights to use, modify and distribute the programs.[33] BSD would later become the basis of Solaris, an operating system by Sun Mircrosystems, as well as for Macintosh's OS X, but by the time BSD was free from AT&T's shackles, Stallman's GNU was way ahead.

Because BSD was *not* free early enough, Stallman did not want to use it as the basis of his free operating system. Instead he decided to write all the pieces from

[32] Ibid., 40.
[33] Ibid.

scratch. As he was putting GNU's puzzle together, Stallman looked at both AT&T's commercial Unix version and the entangled AT&T/BSD version as a reference. One important difference between Stallman's GNU and Berkeley's BSD was the mechanism for software distribution. While the Berkeley Software *Distribution*, as its name suggested, was focused on distribution, GNU shifted the focus from distribution to software development, believing that the users will do most of the distribution on their own, without the FSF's help.[34] Beyond this tactical difference there was a much more profound difference in philosophy that is manifested in the licenses that these two organizations chose for their software. As Nikolai Bezroukov finds, BSD licenses codified an academic tradition of information sharing that was based on proper accreditation. GPL, on the other hand was focused on the creation and maintenance of a general pool of knowledge, a software commons that would grow with time. Bezroukov explains:

> [BSD licenses] can be considered as a codification of a venerable academic tradition. Other works can be used freely by a researcher as long as proper credit was given for the original work. The history of science is a proof that this idea of "proper credit" is a very important and efficient social mechanism. But GPL's advocates a completely different approach … GPL explicitly promotes the "right of the strongest" or "the law of the jungle". The key feature of GPL is protection of the right to redistribute both original work and create and distribute derived works as long as the license is preserved.[35]

In summary, the academic research centers shared Stallman's vision and interpretation of what software could and should be, but at the same time the academics needed to maintain a set of institutional and legal commitments to commercial and government

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[34] Stallman and Rubin, *Gnu's Bulletin Vol. 1 No. 3* ([cited 12/04/08]).
[35] N Bezroukov, *Bsd Vs. Gpl: A Framework for the Social Analysis* [Web] (2002 [cited 05/04 2004]); available from http://www.softpanorama.org/Copyright/License_classification/social_dynamics_of_BSD_and_GPL.shtml.

entities and to their own longstanding traditions of authorship and expertise. This was more than Stallman's social agenda permitted. The FSF was a self-appointed interest group with a clear objective: to change the way people use knowledge and information and to revolutionize the way software is written and distributed. For Stallman and the FSF, Free Software was a moral choice, not only a practical one. In other words, unlike Berkeley's scientists that saw in a BSD a way to ease the tensions around their existing practices, Stallman was determined to set software free. The FSF saw (and still sees) software as a tool in the creation of human knowledge, which should make very specific uses of intellectual property rights (IPR) protections. In fact, as more recent manifestos by FSF's general counsel, Eben Moglen demonstrate, the FSF perceives freeing software as only a first step in a larger civil mission—the abolishment of the intellectual property regime in its entirety.[36] Stallman, for his part, strongly objects to the very use of the term 'intellectual property' in connection to software.[37]

The rise of Linux

During the several years that followed the establishment of the FSF, Stallman was splitting his time between writing code and engaging in social advocacy. His progress was hindered by repetitive stress injuries caused by endless hours of coding.[38] Modeling GNU after Unix, Stallman was able to start his new operating system project by building essential but auxiliary tools like a text editor that he called *EMACS*, while relying on existing Unix components in the interim period. The FSF sponsored itself by distributing software for small sums of money and hired several

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[36] See Eben Moglen, "Anarchism Triumphant: Free Software and the Death of Copyright," *First Monday* 4, no. 8 (1999).
[37] Private communication, 2006.
[38] PG interview

programmers and they started converting to GNU various other software tools. In 1987, an important piece was released, the GNU C compiler, *GCC.* Using *EMACS* for writing and editing, GCC allowed programmers to compile C-language programs based solely on GNU tools.[39] But even with the GCC, for its first half-decade GNU was missing one essential component that Stallman left to the end, the operating system's kernel, a software spine without which GNU could not stand on its own feet. Developing such a kernel proved to be a tricky task whose completion was delayed several times; by 1990 Stallman was working for six years already on his prophetic operating system but no definite target date for the kernel's completion seemed in sight. Despite this fact, word of the GNU project spread quickly, aided by Stallman's evangelical talks and lectures around the world. Stallman was becoming famous in technical circles, and for his work on GNU and for "giving the free software philosophy a voice"[40] in 1990 he was awarded a MacArthur 'Genius' grant of US $240,000. The grant helped him finance his operation for the next several years.[41] In the same year several GNU supporters realized that there was business potential in Free Software. Michael Tiemann and John Gilmore, early GNU supporters started a company called Cygnus, which offered customization services for GNU programs to any party interested in paying for them. They were soon able to book contracts in excess of US $700,000, demonstrating the general enthusiasm in which GNU was accepted in the market.[42]

In 1991, Stallman was still working on developing GNU's kernel when a surprising development occurred. A young undergraduate student, Linus Torvalds, of

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[39] Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software*, 131.
[40] Ibid., 135.
[41] Stallman, *Richard Stallman Biography* ([cited 12/04/08]).
[42] Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software*, 133. In 1999 Cygnus was acquired by Red Hat Linux for US $674M, see Scott Berinato, "Red Hat Buys Cygnus for $674m," *PC Week*, November 15th 1999. See further discussion of Red Hat below.

whom Stallman had never heard, developed a kernel for GNU while working from his university dormitory room at the university of Helsinki, thousands of miles away from Stallman's office in Cambridge, Massachusetts. Torvalds's kernel was the last component necessary to make Stallman's GNU operating system fully functional, and fitted it like a hand to a glove.[43] How could this happen? How could a student develop an essential piece of technology that worked so tightly with software written by one of the world's most famous hackers without ever coordinating this feat? To understand this I now look at the changing landscape of computer science education at that time.

The rise of computing in general, and personal computers particularly, created new disciplines like computer science and software engineering, and the need to create educational programs to train for them.[44] Within this context, operating systems presented not only research problems but also educational challenges. A new and important task of newly established Computer Science (CS) departments was the education of a younger generation of computer scientists in the theory, practice, and operation of computer systems. What was the best way to teach young students the workings of operating systems? Clearly, the ability to see the internals of an operating system was a great aid, and thus Unix's openness and portability made it very attractive as an educational platform, making it the operating system of choice in many teaching centers throughout the 1970s. In 1979, however, ten years after Unix was invented, AT&T changed the terms of Unix's license. It shipped Unix version 7, which contained a warning that the source code couldn't be shared with students anymore. Moody, who wrote a popular history of Linux, finds that "Version 7 represented the symbolic closing of Unix inside the black box of proprietary

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[43] Moody, *The Rebel Code : The inside Story of Linux and the Open Source Revolution*, Ch. 2,3.
[44] For a detailed history see Michael S. Mahoney, "The Roots of Software Engineering," *CWI Quarterly* 3, no. 4 (1990), Michael S. Mahoney, "Software as Science - Science as Software," in *History of Computing: Software Issues*, ed. Ulf Hashagen, Reinhard Keil-Slawik, and Arthur Norberg (Berlin: Springer Verlag, 2002).

software—a sad end to what had long been the ultimate student hacker's system."[45] Without the source-code teaching an operating system became a complicated and slow process.[46] The teaching community needed an alternative and a professor named Andrew Tanenbaum from the Free University in Amsterdam stepped up to the challenge.

As he told Moody, Tannenbaum appreciated teaching Unix, and was very disappointed when AT&T changed the licensing terms and made the code unavailable to his students. He thought of ways to bypass the problem but reached the conclusion that the only solution would be to re-write a Unix-clone without using any of AT&T's code.[47] By now this line of hacker reasoning sounds familiar to us. As in the cases of GNU and BSD, the ultimate hacker solution to a black-boxing crisis is to rewrite the software from scratch and by doing so to disengage from the score of legal, ethical, and institutional commitments associated with a former software distribution. Such a rewrite effort allows the new developer to focus on his own problem-solving process that is based on his interpretation of the problems that the software is aimed at solving. I will return to this point later when discussing the structure of FOSS communities and the possibilities for forking.

Tanenbaum went ahead with his plan and from 1979 to 1984 worked on coding his version of a small Unix-compatible system that he called Minix. At the time Minix was released, Stallman had just started working on GNU and was exploring potential kernels for it. When he heard of Minix he hoped to join forces with Tanenbaum and use Minix's kernel for GNU. Tanenbaum, however, was not motivated by social ideals

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[45]Moody, *The Rebel Code : The inside Story of Linux and the Open Source Revolution*, 33.
[46] I remember spending many frustrating hours in the computer labs during my own computer science training in the early 1990s, trying to understand how a non-open version of Unix really worked. The only relief was a comical poster on the wall that read: "Unix is a very user friendly system, it is just very selective on who it makes friends with."
[47]Moody, *The Rebel Code : The inside Story of Linux and the Open Source Revolution*, 33.

and was trying to solve a completely different problem. He was trying to create a teaching-tool for computer science schools that would be well documented and easy to use. He thought that the whole idea of free software is “silly” and that it makes no economic sense.[48] Instead of giving his kernel for free, he was willing to exchange the kernel for Stallman’s auxiliary applications and utilities like EMACS, and build a commercial system out of the GNU/Minix combination. He proposed to Stallman to share future revenues that would result from sales of the joint system, but Stallman rejected the offer to sell ‘free software’ and decided to continue and work on his own GNU kernel.[49]

Seven years later Stallman’s effort had made GNU famous but it still lacked a kernel while Minix was what it was designed to be—a stable, simple to use, and well documented operating system, which was perfect for educational purposes. Minix was a natural choice for Torvalds, a young computer science undergraduate student with an interest in computing. Torvalds purchased his first computer and excitedly installed Minix on it, but he soon found out that it was too ‘small’ for him.[50] As it turns out, the flip-side of designing a straightforward system is that its simplicity limits its functionality, and this apparently was the case for Minix, in Torvalds’s view. Tanenbaum consistently opposed complicating his system or adding new features to it. For his needs, the system was stable.[51] From my analytical perspective, Minix had reached closure on Tanenbaum’s terms, and perhaps on those of the CS department where he worked, and he therefore saw no need to change it. But in Torvalds’s eyes, Minix lacked essential features, particularly within the context of a software application called a *terminal emulator* that would allow him to connect to the

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[48]Ibid., 22.
[49] Ibid.
[50] Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*, 76.
[51] Andrew S. Tanenbaum and Albert S. Woodhull, *Operating Systems: Design and Implementation*, 2nd ed. (New York, NY: Prentice Hall, 2001), 14-15.

university computer system. Torvalds started writing his own terminal emulator program in order to work independently of Minix. After a few months of work he suddenly understood that using Minix as scaffolding, aided by Tanenbuam's extensive documentation and by library manuals that documented Sun Microsystem's Unix, he could actually build an alternative operating system.[52] On August 25, 1991 he posted a message to an electronic message board known as the Minix newsgroup.[53] His message reads as follows:

> Date: Sun, 25 Aug 1991 20:57:08 GMT
> Reply-To: INFO-MINIX@UDEL.EDU
> Sender: INFO-MINIX-ERRORS@PLAINS.NODAK.EDU
> Comments: Warning -- original Sender: tag was info-minix-request@UDEL.EDU
> From: Linus Benedict Torvalds <torvalds@KLAAVA.HELSINKI.FI>
> Subject: What would you like to see most in minix?
>
> Hello everybody out there using minix -
>
> I'm doing a (free) operating system (just a hobby, won't be big and professional like gnu) for 386(486) AT clones. This has been brewing since april, and is starting to get ready. I'd like any feedback on things people like/dislike in minix, as my OS resembles it somewhat (same physical layout of the file-system (due to practical reasons) among other things).
>
> I've currently ported bash(1.08) and gcc(1.40), and things seem to work. This implies that I'll get something practical within a few months, and I'd like to know what features most people would want. Any suggestions are welcome, but I won't promise I'll implement them :-)
>
> Linus (torvalds@kruuna.helsinki.fi)
>
> PS. Yes – it's free of any minix code, and it has a multi-threaded fs. [file system] It is NOT portable (uses 386 task switching etc), and it probably never will support anything other than AT-harddisks, as that's all I have :-([54]

[52] Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*, 78-9.
[53] Newsgroups or usenet groups are electronic message boards that are divided by topics of interest and are open for reading and posting by anyone with a computer and access to the network.
[54] Torvalds posting to comp.os.minix see Linus Torvalds, *What Would You Like to See Most in Minix?* [newsgroup posting] (comp.os.minix, 08/25/91 1991 [cited 05/17 2004]); available from http://listserv.nodak.edu/scripts/wa.exe?A2=ind9108d&L=minix-l&F=&S=&P=4457.

Torvalds's new pet-project turned out to be something that other hackers were waiting for. Ari Lemke, for one, a teaching assistant at the technical university of Helsinki was intrigued by some of Torvalds's earlier postings on the electronic message board, and gave Torvalds some free space on his university computer system to publish whatever files he wrote, and see what happens.[55] Within hours of Torvalds's posting, more readers started responding. Peter Holzer from the technical university in Vienna, for example, wrote: "…I am very interested in this OS. I have already thought of writing my own OS, but decided I wouldn't have the time to write everything from scratch. But I guess I could find the time to help raising a baby OS :-)"[56] A survey of these early messages shows that Holzer's response was typical. The messages further show how within the next several weeks a group of interested hackers coalesced around Torvalds's efforts and helped him in adding virtual memory, a graphic user interface and networking capabilities to the budding software. At this stage of the project's life, these people never met in person. They communicated over email and Minix's electronic message board while Torvalds concentrated their code contributions and released it back to all interested parties. One person that didn't like Torvalds's new endeavor was Andrew Tannenbaum, Minix's creator. Torvalds entered into a series of electronic message exchanges with him, debating the appropriate way to build operating system kernels.[57] The debate soon heated up and the professional discussion deteriorated into mutual insults. Torvalds decided to start a new newsgroup, which was dedicated to what he now named Linux, after his username on the Technical university's computer system. This departure from the Minix newsgroup

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[55] Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*, 80.
[56] Peter J. Holzer, *Re: What Would You Like to See Most in Minix?* [newsgroup posting] (comp.os.minix, 08/25/91 1991 [cited 05/17 2004]); available from http://listserv.nodak.edu/scripts/wa.exe?A2=ind9108d&L=minix-l&D=0&P=5677.
[57] Andrew S. Tanenbaum, *Linux Is Obsolete* [Newsgroup Posting] (comp.os.minix, January 29th 1992 [cited December 2nd 2006]); available from http://www.educ.umu.se/~bjorn/mhonarc-files/obsolete/msg00000.html.

was more than symbolic. From my analytic perspective I can say that it allowed Torvalds to start building a new technological frame. In this case again a significant software development effort is replicated because the different groups' interpretive flexibility cannot be reconciled. Torvalds chose to start a new operating system because he found it easier to re-develop than to negotiate with Tanenbaum the meaning of Minix.

Torvalds now needed to choose the terms of distribution of his budding operating system. When choosing a license, Torvalds was concerned less with social advocacy and more with ensuring that future modifications would always be available for incorporation into the main development branch, a property that the sophisticated copyleft clause of the GPL enforces, so he decided to release Linux under the GNU GPL.[58] Technically, Linux was already designed to make use of the valuable tools that were developed for GNU. Selecting the GPL for Linux created a GNU/Linux bundle that was not only technically integrated but which had consistent licensing terms. In fact, with the release of Torvalds's kernel, Stallman's decade-old vision of a fully functional, modifiable, yet free operating system was finally realized.

As Torvalds admits, his motivation was very different from Stallman's. He only saw Stallman once, at a lecture that Stallman delivered in Helsinki, and he was not interested in the politics of free software. He writes: "I was not really all that aware of the Free Software Foundation…and all that it stood for…I was interested in the technology, not the politics."[59] Moreover, Torvalds was not interested in changing the way people treat knowledge. He was after proving his technical prowess. He writes:

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[58] Moody, *The Rebel Code : The inside Story of Linux and the Open Source Revolution*, 78.
[59] Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*, 58.

> One of the main reasons I distributed the operating system was to prove that it wasn't all just hot air, that I had actually done something. On the Internet, talk is cheap. Regardless of what you do, whether it be operating systems or sex, too many people are just faking it in cyperspace. So it's nice, after talking to a lot people about building an operating system to be able to say "See, I actually got something done.[60]

Later in this chapter, I will return to this question of how diversely motivated individuals can collaborate so closely not through the price signaling or an institutional hierarchy but by using alternative modes of organization. As I shall discuss in details below, two of the characteristics of FOSS communities are (a) that they allow diversely motivated individuals to cooperate without having to agree on the meaning of the joint result; and (b) that allowing individuals to self-select tasks and interpretations becomes a key feature in this class of systems.

Figure 3-1 summarizes the timeline of the different development attempts I surveyed (and some I will describe shortly), as well as some of the resulting operating systems of today. From the social constructionist perspective, it is important to note that Unix, BSD, GNU, Minix and Linux each constituted their own technological frame. Unix was the heavy-duty, for profit, professional, operating system targeting real-world applications. BSD was the research alternative, promoting core computer science research interests. Minix targeted the group of academics who were interested in operating systems and its simplicity was a direct result of the environment's educational needs. Minix was never designed to perform any real world tasks, and there was no need to continue its development. GNU, in parallel, had its social aspirations built into its design in the form of the GPL and free distribution practices. GNU was designed to *not* be what other systems were, namely, closed, expensive, and hard to modify. Arguably, before it became a technological frame of its own,

[60] Ibid., 88.

GNU/Linux was the result of Stallman and Torvalds's inclusion within the technological frames of research, education, and commercial software development. Analyzing the degree of inclusion of key actors in these frames is useful when trying to explain the motivations of the four cases in which the hackers involved showed a tendency to re-write their operating system almost from scratch instead of changing an older system.

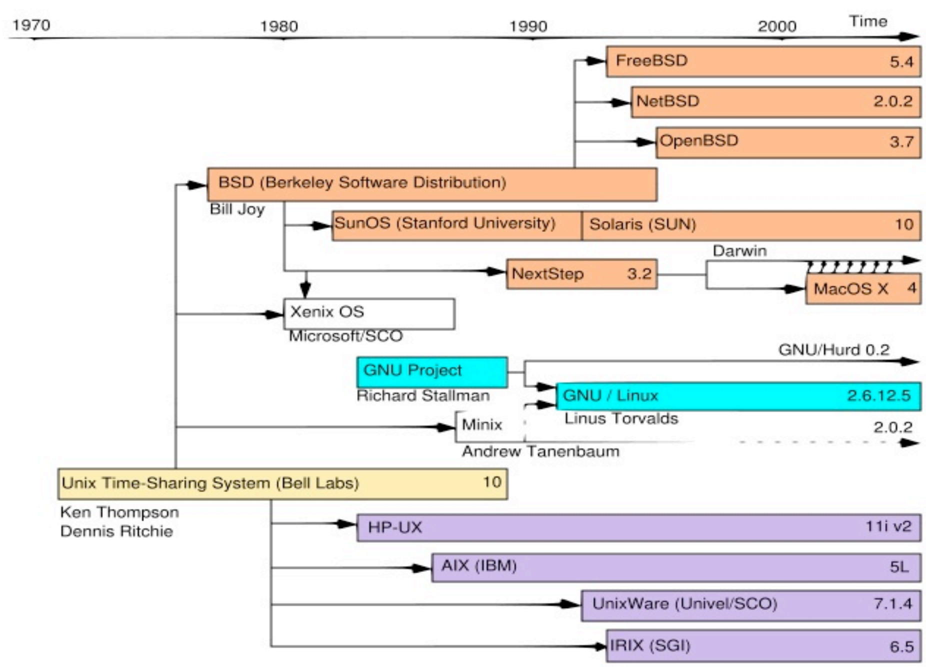

Figure 3-1: Different versions of Free Software[61]

I want to suggest that these four cases demonstrate how actors with low levels of inclusion in an existing technological frame chose to constitute a new technological frame in which they will have a higher level of inclusion that would, in turn, translate

[61] Source: Wikipedia: Linux.

to better control on both the technology and the social environment upon which it rests—the respective developer community. This is important because one of the lessons learned by these actors, particularly Stallman, was that the process of building these systems was long and expensive. I read the drafting of the GPL as Stallman's attempt to constitute a new frame with regards to technology, that of 'free software', whereby the social and legal mechanisms guarantee future generations' freedom. The GPL was meant to ensure that GNU would always be open for modification. As I argue below, embedding this ideal in the legal mechanisms that controlled GNU/Linux posed a problem for other groups. A battle on the future of Free Software quickly ensued.

From Free Software to Open Source

During the following several years Stallman and Torvalds worked independently on getting GNU/Linux off the ground. With Linux becoming the de-facto standard kernel, Stallman continued his advocacy attempts while Torvalds, aided by the rise of the World Wide Web[62] which made computer networking readily available for home use, began marshaling from his home a growing community of developers. Because early versions of GNU/Linux included all the development tools necessary to continue and develop applications that extend the operating system's basic functionality, anyone that had the motivation, programming skills, and an Internet connection could in principle become a part of a growing community of GNU/Linux users and developers. As is evidenced by my analysis of the traffic of the Linux kernel mailing lists, the developer community was growing daily; in the few

[62] The first website became available in August 1991. In 1993, CERN made the Web free to anyone. The See Wikipedia: World Wide Web. For a detailed history of this period, see James Gillies and R. Cailliau, *How the Web Was Born : The Story of the World Wide Web* (Oxford: Oxford University Press, 2000).

months following its October 1991 launch, traffic on Torvalds's message board grew to several hundreds messages a week. The number soon grew to thousands.[63]

Torvalds and his first followers like Alan Cox and Greg Kroah-Hartman, both British hackers, and other 'lieutenants' as they later became known, fostered a more egalitarian environment of openness and transparency than was accepted in older Unix projects.[64] Torvalds's original Minix post and the many messages that followed show how the Linux project promoted participation at all levels and called for code contribution, bug reports, documentation, and anything else that would help promote it. Authority was established by personal charisma and the level of work put in the project and was measured by the participants' loyalty. I will go into these mechanisms in much depth below. For now, it is sufficient to note, as Coleman points out, that the hackers who helped Torvalds write the Linux kernel and the programs that followed were not motivated by a political desire to pursue freedom or resist the tightening IPR regime. Most of them were simply excited by the opportunity to access the Unix-like operating system, which they could use on their home computer and also improve.[65]

As the number of people involved with free software grew, so did the attitudes towards it. In particular, among the many people who had come to use free software and Linux, some were getting uneasy with Stallman's politics.[66] As I discuss in details below, in the face of free software's growing potential and signs of early adoption in the business sector, to some hackers, Stallman's concern with users' freedoms seemed detrimental to the opportunity of changing the way software is written, distributed and

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[63] *Linux Kernel Historic Archives* [Web] (June 3rd 2003 [cited December 3rd 2006]); available from http://www.kclug.org/old_archives/linux-activists/. Also see comments on the Linux Kernel Traffic project below.

[64] Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition", 332.

[65] Ibid., 152.

[66] For a detailed discussion of this point, see Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software*, 156-7.

used. People like Eric S. Raymond, a hacker from Pennsylvania, critiqued Stallman's micro-management style that made GNU projects rigid.[67] According to his own account, Raymond became familiar with Stallman's brilliance and limitations while contributing code to Stallman's EMACS project during the late eighties. His contributions earned him respect within the hacker community, but by 1992 he distanced himself from the project after a quarrel with Stallman who wanted to control Raymond's EMACS modifications. Raymond was not the only one concerned. By February 1996, when the first engineering conference dedicated to free software convened in Cambridge, Massachusetts, sponsored by the FSF and having both Stallman and Torvalds in attendance, it was clear that there were two camps within the free software community. In one camp were Stallman and older hackers who chose free software as a matter of moral principle. In the other camp were Torvalds and a growing group of younger hackers who saw in free software a better way to make software but did not necessarily want to completely abolish proprietary software.[68] They wanted to enjoy both the world of commercial software and that of free software for what they believed each was worth. Unlike Stallman, the latter group had no claim to a moral high ground. Torvalds's easygoing attitude towards free software is perhaps best captured by his later statement, which adorns the back-cover of his autobiography a few years later: "Software is like sex, it's better when it's free."[69] It represents his playful attitude to the whole story. The title of his memoir is "Just For Fun."[70]

Observing Linux's growth closely, Raymond realized that Linux offered a new and superior software development methodology. What allowed Linux to grow so fast and to remain so stable, Raymond believed, was the fact that Torvalds did not have

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[67] Ibid.
[68] Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software*.
[69] Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*, Back cover.
[70] Ibid.

central control, that he released versions often, and that the he allowed contributors to self-select their tasks. To test the Linux collaborative model, Raymond decided to develop a project called 'fetchmail' that allowed accessing e-mail from remote sites. The project was very successful and widely adopted, and Raymond published his conclusions, first as a speech he delivered in free software conferences and later in a paper that became very influential. Titled *The Cathedral and the Bazaar,*[71] the essay looks at how software is written, debugged, and used under two very different development styles, the 'cathedral' and the 'bazaar'. In the 'cathedral' model used by most of the commercial world but also by the GNU project, software is written in a hierarchical, centralized manner; in the 'bazaar' model of the Linux world, software is built collaboratively, by groups of self-appointed volunteers. Raymond argues that one key difference between the models is the relation to the debugging task, which, as every software engineer knows, is at the heart of the software development process. Raymond writes:

> [In the bazaar model] every problem "will be transparent to somebody"…the person who understands and fixes the problem is not necessarily or even usually the person who first characterizes it…But the point is that both things tend to happen quickly. Here, I think, is the core difference underlying the cathedral-builder and bazaar styles. In the cathedral-builder view of programming, bugs and development problems are tricky, insidious, deep phenomena. It takes months of scrutiny by a dedicated few to develop confidence that you've winkled them all out. Thus the long release intervals, and the inevitable disappointment when long-awaited releases are not perfect. In the bazaar view, on the other hand, you assume that bugs are generally shallow phenomena -- or, at least, that they turn shallow pretty quickly when exposed to a thousand eager co-developers pounding on every single new release. Accordingly you release often in order to get more

[71] Raymond, *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*.

> corrections, and as a beneficial side effect you have less to lose if an occasional botch gets out the door. And that's it. That's enough.[72]

Notice that Raymond never mentions any social causes, he never aims to change the way people treat knowledge, and he is not concerned with licensing schemes that would ensure future freedoms. Instead, he promotes a pragmatic approach, whereby Linux-style development is considered better simply because it allows faster, more reliable software development. Raymond soon had a first-hand experience of how compelling his argument was. Several Netscape engineers were present at a talk he gave at a developer conference in California, and took the ideas to their boss, Jim Barksdale who was trying to devise strategies to regain the market share that Netscape was quickly losing to Microsoft in the Internet browser wars.[73] In an attempt to re-invent Netscape Barksdale decided to release the source code of Netscape's software and switch from the cathedral model to that of the bazaar. Raymond's paper was quoted as one of the influences on their decision, and he was invited to help Netscape coordinate the operation.[74]

Following Netscape's decision, Raymond realized that the time was right for creating a new framework that would better accommodate the Linux model in a business environment than Stallman's free software ideas could. He partnered with Bruce Perens, a prominent hacker and a key figure in the Linux community, and with several other leading hackers and activists, including publisher Tim O'Reilly, VA Research president Larry Augustin, and Jon Maddog Hall from a Linux advocacy group called Linux International. They called a meeting in Palo Alto, California, on

[72] Ibid.
[73] Netscape's pioneering Navigator software, which was the first widely used browser with almost 100% market share in 1996, was losing out to Microsoft's Internet Explorer. By 1999 Explorer dominated 50% of the market and Netscape was considering their response. See Wikipedia: "Browser Wars".
[74] Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software*, 161.

February 3, 1998 to devise a strategy. As they later recall, the first major challenge was defining their relationship to free software:

> We were reacting to Netscape's announcement that it planned to give away the source of its browser. One of us (Raymond) had been invited out by Netscape to help them plan the release and followon [sic] actions. We realized that the Netscape announcement had created a precious window of time within which we might finally be able to get the corporate world to listen to what we have to teach about the superiority of an open development process. We realized it was time to dump the confrontational attitude that has been associated with "free software" in the past and sell the idea strictly on the same pragmatic, business-case grounds that motivated Netscape. We brainstormed about tactics and a new label. "Open source," contributed by Chris Peterson, was the best thing we came up with. Over the next week we worked on spreading the word. Linus Torvalds gave us an all-important imprimatur :-) the following day… Richard Stallman flirted with adopting the term, then changed his mind.[75]

That same month, despite Stallman's vehement rejections, Raymond and Perens founded a new organization for the promotion of their version of free software, naming it the *Open Source Initiative* (OSI). In an innocent-looking footnote on a later version of the *Cathedral and Bazaar* paper there is a remnant of the bitter controversy between Stallman and Raymond. At the very bottom of the paper Raymond writes: "I changed 'free software' to 'open source' February 9, 1998."[76] While the subtitle of the Cathedral and Bazaar reads "Musings on Linux and open source by an accidental revolutionary" Raymond's choice of a new metaphor to describe an existing activity was, of course, not accidental at all. To be successful in achieving his new goals and to differentiate his organization from the original free software project, Raymond needed to make his intentions clear. The FSF was, of course, aware of the double meaning of the word 'free' as both 'libre' and 'gratis', and whenever possible the FSF prompted

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[75] *History of the Osi* ([cited 12/04/08]).
[76] Raymond, *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*.

people to think of ‘free’ as in ‘free speech,’ not as in ‘free beer’.[77] But Raymond understood that business-people cannot distinguish between these linguistic ambiguities. In a business context free means ‘zero cost’, and free is usually bad for business. Raymond decided to eliminate the conceptual problem by a rhetorical move. OSI changed ‘free’ to ‘open’ and ‘software’ to ‘source’ to emphasize that the new system is compatible with traditional business values. From an analytical perspective, one can read the switching from ‘free software’ to ‘open source’ as Raymond’s attempt at rhetorical closure, and the explicit attempt to open a new technological frame.[78]

This rhetorical move by OSI had long lasting ramifications on the future of free software. Open source projects started getting wide attention in the media and in the computer industry; within less than a year from OSI’s inception, many key players in the computer industry showed support for the growing open source phenomenon. Corporate juggernauts like IBM, Silicon Graphics, Oracle and Hewlett Packard rolled out solutions based on Linux; Apple Computers released the source code of their new operating system under an open-source license; and the open-source Apache project, which by now is the world’s most ubiquitous web-server software, was gaining ground.[79] The media was quick to adopt the new terminology too; within a short while both *Forbes* and the *Economist*, ran major stories on the growing phenomena with Torvalds’s pictures, and these were soon followed by other media reports.[80]

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[77] *Gnu Homepage* [Web] (Free Software Foundation, 2004 [cited 05/04 2004]); available from http://www.gnu.org/.

[78] Pinch and Bijker explain that “closure in technology involves the stabilization of an artifact and the ‘disappearance’ of problems. To close a technological ‘controversy,’ one need not solve the problems in the common sense of that word. The key point is whether the relevant social groups see the problem as being solved.” SeePinch and Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," 44.

[79] *History of the Osi* ([cited 12/04/08]).

[80] Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software*, 164. *History of the Osi* ([cited 12/04/08]).

The name change was soon followed by releasing a new licensing agreement template that was much more permissive than the GPL. It allowed the amalgamation of open-source software with proprietary software in a commercial software distribution without requiring such derivative work to be released under a free software license, a requirement that is central in the GPL. Relaxing this requirement cleared the way for major businesses to adopt open source methodologies without having to compromise future software sales and revenues by making their proprietary knowledge available under the GPL. Both the change in the licensing regime and the rhetorical change were aimed at solving the problem of for-profit businesses. Soon, free software in its new outfit as 'open source', was being imbued with meanings that were far beyond the control of Stallman and the FSF. The term 'open source' was displacing 'free software' as the name for the movement that Stallman had initiated, and he was upset. In Stallman's eyes OSI's move was simply a betrayal. He felt that the revolution that he had started was being hijacked away from him. In an email he wrote to me he said:

> We [at the FSF] believe that it is unethical and antisocial to prohibit other people from cooperating when they wish to (e.g., by distributing non-free software.) The Open Source movement was formed in 1998 to reject that view. They have had lots of PR aid from business, and as a result many people mislabel our software, our community…[81]

Stallman was not the only one that was unhappy. Surprised by the outcome of his own moves, Bruce Perens, co-founder of the OSI had a change of heart. In February 1999 he resigned from the OSI and sent a message to a Linux developer group that explained his new-old belief:

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[81] The quote is taken from source materials of Shay David, "On Source Scapes and Filescapes: Towards a Critique of the Political Economy of Free and Open Source Software" (Master's Thesis, New York University, 2003).

> About a year ago, I sent out a message announcing "Open Source". Eric Raymond and I founded the Open Source Initiative as a way of introducing the non-hacker world to Free Software. Well, thanks to Eric, the world noticed. And now it's time for the second stage: Now that the world is watching, it's time for us to start teaching them about Free Software. Notice, I said Free Software, _not_ Open Source… Open Source has de-emphasized the importance of the freedoms involved in Free Software. It's time for us to fix that. We must make it clear to the world that those freedoms are still important, and that software such as Linux would not be around without them…One of the unfortunate things about Open Source is that it overshadowed the Free Software Foundation's efforts.[82]

In academic circles the terms FOSS or FLOSS (for Free/Libre Open Source Software) try to bind the two parts of the community together, suggesting that to outsiders both flavors of the new types of software are similar. For members of the community these amalgamations are not convincing. Stallman, for one, knows how powerful words can be. When we recently met, (2006) Stallman tried to convince me to change any references I was making to 'the open world' into the 'free world' in order to prevent 'further confusion' about the sort of systems I aimed to explore.

The bigger picture: FOSS in the eyes of proprietary software vendors

While internal schisms were dividing the free software / open source communities, their combined effect was exerting pressure on the entire computer industry. Companies within the computer sector had to react to this tectonic plate movement. For companies like IBM and Novell who made most of their money in selling hardware, the reaction was easy: GNU/Linux represented an opportunity to reduce the cost of their solutions by reducing the cost of software. For other companies like Sun Microsystems, which marketed a combination of hardware and

[82] Bruce Perens, *It's Time to Talk About Free Software Again* [Usenet] (debian-devel@lists.debian.org, February 17th 1999 [cited November 15th 2006]); available from http://lists.debian.org/debian-devel/1999/02/msg01641.html.

software, the situation was more complicated because it represented both a risk and an opportunity. For companies like Microsoft whose business was writing and selling proprietary software, FOSS's rise meant an all-out war.

By the year 2000, IBM decided to put its weight behind Linux and pledged that it would invest US $1 billion in hiring open source programmers and promoting open source projects. The reasons for which *Big Blue* did this are purely economic; Linux allowed IBM to unite its global offering. Covering IBM's move, the *Financial Times* found that: "IBM is promoting Linux as a lingua franca that helps it unite its own different computing platforms, which range from PCs to supercomputers. By encouraging software developers to create applications for Linux, those applications can more easily run on any computer system that runs Linux, which in turn will help drive sales of IBM's computer systems and services."[83] The pledge resulted in support for existing products and the start of new products such as IBM's software development environment called *Eclipse*. Such moves were accepted with applause in both open source and free software circles; open source advocates were beginning to see their vision of open source based business come true while free software advocates were willingly cooperating with any entity that promoted free software, without checking their motives. Clearly there is a symbiotic relationship here between developer communities and business entities, which is based on a delicate balance of shared interests.

The case of companies like Sun Microsystems complicates the picture and shows how for companies with different business models adoption of the open source paradigm was much slower. Sun was co-founded in 1982 by Bill Joy, a graduate student at Berkeley and one of the chief architects of Berkeley's BSD, a feat that

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[83] Tom Foremski, "Big Blue's New-Found Faith Has Linux Groups Leaping," *Financial Times*, December 15 2000.

earned him the title “the Edison of the Internet” by *Fortune Magazine*.[84] On the one hand, Joy was clearly a significant contributor to the free software / open source phenomena but on the other hand he soon became a successful business man, a billionaire from his Sun stock, and the chief scientist one of the most successful companies in the software industry. Sun was in the business of selling powerful server computers that came bundled with Sun’s proprietary operating system, Solaris™. Solaris was an offshoot of Joy’s BSD taken private. It was BSD’s permissive license terms that allowed Sun to create a completely proprietary version of the software, which it sold to its customers for a large profit. Joy’s participation in the two competing frames of open and proprietary software was, for years, reflected in Sun’s confused strategy. Sensing pressures from its customers that were fast adopting Linux, in August 1998 Sun decided to make Solaris available under a free license to individual users and to educational and non-profit research institutions.[85] However, Sun was not willing to espouse the full implications of releasing its software as open source software and forfeiting the main slice of its US $9 billion revenue pie.[86] In fact for the next several years Sun was trying to eat the cake and leave it whole; it wanted to satisfy the developers’ community and its customers who wanted access to the source code but at the same time it wanted to protect its profitability. This mixed interest produced a confused strategy and licensing terms that to people like Torvalds seemed idiotic.[87] For the next several years Sun danced around Linux and formed its

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[84] B. Schlender, *The Edison of the Internet* [online magazine article] (Fortune Magazine, February 15th, 1999 1999 [cited 05/04 2004]); available from http://www.fortune.com/fortune/articles/0,15114,376666,00.html.

[85] *Press Release: Sun Aggressively Expands Developer Base for Solaris Operating Environment.* (Sun Microsystems., August 10th 1988 [cited November 17th 2006]); available from http://www.sun.com/smi/Press/sunflash/1998-08/sunflash.980810.2.html.

[86] On the same press release there is a specific warning: “Use of the Solaris operating environment secured through this offer is limited to non-commercial use only. Participants are free to develop and test applications, but in order to deploy them for commercial use, they must upgrade their software to a commercial license.” (Ibid)

[87] Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*, 152-3.

own strategy around open source. On one hand it released a set of products centered around Linux but on the other hand it still made the proprietary Solaris the core of its offering.[88] In the meantime, after being highly profitable in the 1990s Sun started losing money as customers shifted to IBM's Linux solutions. Finally in 2005, after Sun's sales dropped dramatically, Solaris was released as a fully open sourced software package.[89] A similar confusion is true for Sun's other software innovation, the Java operating system. For years it has been rumored in the industry that Sun will 'soon' open the source code for Java. In 2006 Sun finally outlined a plan to do so and started to release parts of the code.[90] Overall I see in Sun's story an example of how the free and open source software frame was disrupting existing business models, and how software giants slowly but surely were gravitating towards the new model.

Microsoft, unlike Sun, never understood the value of open source. Bill Gates, Microsoft's founder, outlined his ideas about the meaning of software as early as 1976, when he sent an "open letter to hobbyists." Intended for the hackers at MIT's AI lab where Stallman worked, as well as to the other developer communities and early adopters of Gates's BASIC programming language, the letter discusses the future of software as Gates saw it. Using normative language Gates tries to convince hobbyists and hackers that the biggest problem they have with software is that good software doesn't exist because their sharing ethic diminishes the motivation for anyone to spend resources and produce it. Gates writes:

> To me, the most critical thing in the hobby market right now is the lack of good software courses, books and software itself. Without good software and an owner who understands programming, a hobby

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[88] Andy Patriziol, "Linux Moving to Heart of Sun," *Wired News*, February 8th 2002.
[89] *Press Release: Sun Announces Open Source License for Solaris Operating System* [Web] (Sun Microsystems, January 25th, 2005 2005 [cited November 17th 2006]); available from http://www.sun.com/smi/Press/sunflash/2005-01/sunflash.20050125.1.xml.
[90] Dan Farber, *Sun Outlines Java Open Source Roadmap* (ZDNeet, August 14, 2006 2006 [cited November 19th 2006]); available from http://blogs.zdnet.com/BTL/?p=3493.

> computer is wasted. Will quality software be written for the hobby market?… As the majority of hobbyists must be aware, most of you steal your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid? Is this fair? … One thing you do do is prevent good software from being written. …I would appreciate letters from anyone who wants to pay up, or has a suggestion or comment…Nothing would please me more than being able to hire ten programmers and deluge the hobby market with good software.
>
> Bill Gates, General Partner, Micro-Soft[91]

Gates's description of the hacker community and early computer users as a 'market' -- and not a community, or a club-- clarifies that what he perceived as the problem was that he couldn't engage in a profitable exchange with them. It's also a clue to the future of his venture. A decade later, by 1998 Micro-Soft, which later became Microsoft, was neither small nor soft. Despite what Gates called 'theft' of his software by hobbyists, Microsoft and the other firms that followed it were able to create a real market for proprietary software. For over two decades Gates rode the waves of the computer revolution audaciously, making excellent business decisions along the way, most notably, negotiating a deal with IBM according to which Microsoft would license to IBM an early version of the Disk Operating System (DOS) while keeping the intellectual property rights to itself. In a process that deserves a full social constructivist analysis of its own (but is beyond the scope of this work) Microsoft became the world's largest and most profitable software company, 'Windows' became synonymous with 'operating system', and the world of commercial operating systems had ostensibly reached closure. That is, until the free and open source software beast raised its head. By 1998, Microsoft could no longer ignore the changes that FOSS was bringing about.

[91] W. Gates, *Open Letter to Hobbyists* [Web] (February 3, 1976. 1976 [cited 05/04 2004]); available from http://www.blinkenlights.com/classiccmp/gateswhine.html.

During the last week of October 1998, a confidential Microsoft memorandum on the company's strategy against Linux and Open Source software was leaked to Eric Raymond. Raymond released the document over Halloween weekend to the national press, and it became notoriously known as the 'Halloween document'. Published widely, and authenticated as original by Microsoft after public pressure, the document that was put together by Microsoft employees alerts Microsoft's management to the perils they should expect from the new creature that was invading Microsoft's habitat. It reads in part:

> OSS [Open Source Software] poses a direct, short-term revenue and platform threat to Microsoft, particularly in server space. Additionally, the intrinsic parallelism and free idea exchange in OSS has benefits that are not replicable with our current licensing model and therefore present a long term developer mindshare threat.
>
> Recent case studies (the Internet) provide very dramatic evidence... that commercial quality can be achieved / exceeded by OSS projects....to understand how to compete against OSS, we must target a process rather than a company.
>
> Linux and other OSS advocates are making a progressively more credible argument that OSS software is at least as robust -- if not more -- than commercial alternatives. The Internet provides an ideal, high-visibility showcase for the OSS world. … The ability of the OSS process to collect and harness the collective IQ of thousands of individuals across the Internet is simply amazing. More importantly, OSS evangelization scales with the size of the Internet much faster than our own evangelization efforts appear to scale.[92]

What is important to note in this document is the importance the authors grant to the developer community, whose mindshare they are afraid to lose. Although Microsoft makes most of its money from selling software to people who don't know anything about computer programming, it is clear to Microsoft that in order to ensure that their

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[92] V. Valloppillil and Cohen J., *Open Source Software: A (New?) Development Methodology* [Web] (October 1988 [cited 05/04 2004]); available from http://www.opensource.org/halloween/halloween1.php.

captive audience remains captive, the developers should be convinced first. Parallelism and free idea exchange are perceived as a threat to Microsoft which is a hierarchical firm and which is used to competing with other companies, and not with processes. The reference to the general user-base is through the concept of evangelism. Linux is dangerous because it is able to evangelize itself better using the Internet. In analytical terms: the danger that Microsoft perceives is that it might lose hold on the problem definition for the largest relevant social group. Linux can sway the users to support it by better defining their problems. Clearly for Microsoft an operating system has a different meaning than for the open source community. For Microsoft, just like for LMI and Symbolics two decades earlier, software is first and foremost a tool for making money. Cynically perhaps, Microsoft managers were interested in the bottom line more than in any specific line of code. For the open source community, software is first and foremost a collaborative process for solving problems. They are focused on the method. Although OSI's rhetorical moves were aimed at alleviating this tension between methodology and outcomes, Microsoft was not convinced. Just like Sun Microsystems, Microsoft, too, established a stronghold over developer communities by creating a marketplace for them to sell their solutions. FOSS and the alternative structures for software sharing and effort sharing that it represented was endangering Microsoft's model. Microsoft and FOSS projects represent two competing models for control over the developer community, and thus the user community. Microsoft allows developers to make money by selling software. FOSS allows developers to make money by selling auxiliary services, but its main allure is not economic.[93] Could these models be reconciled?

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[93] For a detailed discussion of open source business models see Weber, *The Success of Open Source*, Ch. 7.

Redefining the problem, Red Hat and Open-Source business models

As it became clear that FOSS was a viable alternative for businesses, there were people who tried to find a synthesis between these two competing models. Bob Young, the chief executive and co-founder of Red Hat software, a leading Linux distributor, was one of these people. Young understood early on that if any sort of stability should be attained for free software and open source, the problem that open source software creates should be reformulated. Like others before him, Young understood that the way to get to the users passes through developers and software companies. As in Microsoft's view, the key problem with open source software that developers had is simple: by giving away the software, they ostensibly had to give away their revenues, an idea that for the Microsofts of the world was not an option. But Young was able to think of the problem differently. He realized that what software companies really wanted was to make money not sell software. The question that needed to be asked, then, is not "how do you make money by selling free software?" but, rather, "how do you make money **in** free software?" It was clear to him that it was not going to be easy, but he believed that the similarities between free and proprietary software are greater than many advocates were willing to admit. He writes:

> No one expects it to be easy to make money in free software. While making money with free software is a challenge, the challenge is not necessarily greater than with proprietary software. In fact you make money in free software exactly the same way you do it in proprietary software: by building a great product, marketing it with skill and imagination, looking after your customers, and thereby building a brand that stands for quality and customer service.[94]

[94] Robert Young, "Giving It All Away: How Red Hat Software Stumbled across a New Economic Model and Helped Improve an Industry," in *Open Sources: Voices from the Computer Revolution*, ed. Chris DiBona, Sam Ockman, and Mark Stone (Beijing: O'Reilly Associates, 1999), 114.

Young's idea rests on the premise that even in FOSS environments users are still willing to pay for packaging, distribution, maintenance, and professional services. Selling the software itself is only one part of a bigger transaction, and according to Young it isn't the most important part. Moreover, once the developers are convinced that they can make money, they will focus on seeing the huge advantages that open source has: better control for the user. The discussion could shift from the problems the developer faces to the problems the users encounter: "Open-source code is a feature. Control is the benefit: Every company wants control over their software, and the feature of open source is the best way the industry has found so far to achieve that benefit."[95]

The short history of Red Hat software, the company Young co-founded and headed show how his ideas worked in practice.[96] Red hat started out by distributing packages of Linux developed by others but soon became a powerhouse for Linux development, testing, and professional services. Red Hat supported free software in the strict legal sense: all of Red Hat's software packages were (and still are) distributed under the terms of the GPL. Red Hat showed that there is big money in free software. The market opportunity that Young saw sooner than anyone else was simple. Red Hat offered a slew of services that bridged the gap between hacker communities and traditional businesses like Dell, IBM and Sun Microsystems. Red Hat became a clearinghouse for Linux, which guaranteed that the thousands of components that are part of an operating system would indeed be compatible with one another. Red Hat also offered training and support, two elements which were necessary in making Linux a viable option for larger businesses. Selling these auxiliary services around Linux

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[95] Ibid., 123.
[96] A detailed timeline of events is given in *Red Hat History* [Web] (Red Hat Software, 2006 [cited November 24th 2006]); available from http://www.redhat.com/about/companyprofile/history/.

proved to be a very profitable venture in a very short time. Red Hat attracted significant funding and eventually went public in August 1999 in one of the most successful initial public offerings of Wall Street history.[97] The stock options that Red Hat (and other companies) awarded to free software mavens like Torvalds for their principle contribution to Linux made them millionaires overnight. Richard Stallman, rejected the stock options he was offered.

In Red Hat's and other commercial FOSS providers' offerings the meanings of free software are again debated. In contrast to Young's vision that stresses the control aspects, my own experiences in the software industry show that commercially available FOSS packages are increasingly perceived as good alternatives to proprietary software mainly because of their cost-effectiveness and not because of the freedom they offer. Free software is often free as in beer, not only as in speech. Cost saving is at the heart of almost any business strategy, and FOSS seems to offer just that: low cost, reliable, software. For this reason the debates surrounding FOSS are often reduced to economics in general and calculations of 'total cost of ownership' particularly. Proprietary-software vendors and FOSS advocates use this economic rhetoric alike, but FOSS vendors stress how attractive pricing is on the side of FOSS. Proprietary vendors like Microsoft have a real problem in competing with software that is given for free, and for that reason they want to take the discussion away from pricing. When I recently asked Steve Ballmer, Microsoft's CEO, "how can Microsoft compete with a free product?" he responded "don't say free, say US $50 cheaper."[98] In this response Ballmer aims to highlight the fact that within the total costs associated with owning and running a computer, the embedded cost of Microsoft's operating

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[97] Ibid.
[98] Microsoft CEO Steve Ballmer speaking at the Captains Of Industry lecture series, 92Y, New York, November 19, 2003.

systems are not very high. Microsoft would want to compete on its software merits, and not on price. FOSS users agree that within the total cost associated with operating software, the cost of the software itself might not be a significant portion, but for business users and hardware companies that bundle FOSS in their offering, the price of 'free' FOSS could just as well be the difference between profit and loss. For this very reason Red Hat and its likes are always in danger of alienating their customers by charging too much for their services.[99]

To summarize, Young and Red Hat reconceptuatlized the problem of free software, and were able to build a model that combined both freedom and good business practices. Free software, which started as Stallman's fight against businesses that rejected his hacker ideals, had been imbued with new meanings. In Red Hat's version free software became the subject of very profitable business itself. Red Hat was the first to fully commercialize Linux, and thus gained a first mover's advantage that allowed it to secure the leading role in the market, but soon enough other companies followed. The Internet bubble was at its fullest when VA Research, the long time Unix distributor whose president Larry Augustin was instrumental in the 'open source' name change, changed its name to VA Linux and went public in December 1999 in a historic Initial Public Offering (IPO); its stock soared 698% on the first day of trading, the largest first day gain in NASDAQ's history.[100] The stocks VA Linux awarded to Linus Torvalds, who by that time had moved to Silicon Valley to work for a small hardware manufacturer called Transmeta, were worth, on paper, US $20 million.[101] Eight years after he first started Linux, while still not working on

[99] For example, Red Hat upset Dell and Sun when it raised the fees it charges for packaging, distribution, maintenance, and support of its Linux distribution in 2004. See Ashlee Vance, "Dell Turns on Too Pricey Red Hat," *The Register*, December 8th 2004.
[100] Mark Gimein, *Dissecting the Va Linux Ipo* (Salon.com, December 10th 1999 [cited December 18th 2006]); available from http://www.salon.com/tech/log/1999/12/10/va_linux/index.html.
[101] Torvalds and Diamond, *Just for Fun: The Story of an Accidental Revolutionary*, 175.

the project full time, the student from Finland became a rich person and admittedly he was ecstatic about it.[102] Soon thereafter, in March of 2000, the Internet bubble burst and technology stocks including Red Hat's and VA Linux's deflated, but in Torvalds's eyes the point had been made. If nothing else, the IPOs of Red Hat and VA Linux had proven that Linux was real, and that it was a viable alternative to traditional operating systems. The large market players, companies like IBM, Sun and Novell took note. Linux was not a hackers' toy anymore, it was becoming a major weapon in the arsenal of software giants. Novel, for example, a computer-networking provider was looking to get into the Linux space and in November 2003 acquired SUSE Linux, Europe's leading Linux distributor, which was run by one of Torvalds's friends, for US $210 million in cash.[103] In a few short years Linux, or more accurately GNU/Linux, turned from a hackers' hobby to a significant economic phenomenon that was changing the software industry. As I have noted, this process coincided with the changing of the meaning of Stallman's free software into open source.

The current state of FOSS: doing well and doing good

We now fast forward to see the current state of FOSS. During the last several years Stallman focused most of his efforts on social advocacy, traveling around the world to evangelize free software. Torvalds, meanwhile, kept leading the Linux Kernel development effort while several other developers took charge of developing what became known as Linux distributions or 'distros', for short. Each distro contains a bundle of Torvalds's Linux kernel and a set of utilities and applications such as a graphical user interface, games, and office productivity applications. This diversity is

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[102] Ibid., 174.
[103] *Press Release: Novell Announces Agreement to Acquire Leading Enterprise Linux Technology Company Suse Linux* (Novell Inc., November 4th 2004 [cited December 20th 2006]); available from http://www.novell.com/news/press/archive/2003/11/pr03069.html.

enabled by the terms of the GPL under which GNU/Linux was first distributed, which stipulate that the users retain the rights of redistribution so long as a newly distributed package is distributed under similar terms (this clause in the GPL is known as the 'viral clause.') What this means in practice is that anyone with sufficient motivation can take GNU/Linux and distribute it anew, offering his or her own packaging, testing, distribution, education, or any other services around it. Over the years more than fifty different groups found reasons to develop their own distros.[104] In other words, there is no one product anymore that is GNU/Linux. A partial reason for this diversity is the different attitudes towards the commercialization of Linux. Commercial companies like Red Hat or Novell/SUSE, which maintain most of the leading distros, choose to maintain and distribute their own distros for business reasons. Their existence depends on their ability to offer their customers a better packaged Linux distro, an ability that is tied not only to the software itself but also to the amount of available applications, the level and ease of software upgrades, the level of support, etc. While commercial Linux distros thrive, several other distros are maintained by hackers that keep true to Stallman's original free software ideals. The basis for most of these 'free software' distros is the Debian project, which was started in 1993 by a student named Ian Murdock and was later led by Bruce Perens who, as I noted earlier, was disenchanted with the 'open sourcing' of free software, and promoted free software ideals. Debian is a volunteer-based project that is focused on developing and distributing free software that is developed in an open manner.[105] Today Debian includes over 15,000 software applications for a variety of hardware architectures. Debian's organization and its reliance solely on the work of volunteers highlights the schism in the FOSS

[104] For a complete list see Wikipedia: Comparison_of_Linux_distributions

[105] For a comprehensive review of Debian and a discussion of its history and social structure see Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition".

community where there has been a recent trend of commercialization. Recent research tried to evaluate just how large Debian is. The study showed that Debian (Version 2.2) includes more than 55,000,000 lines of code, and that despite the project's global geographical distribution and decentralization, it was larger than any other Linux distro. The researches estimated that it would have cost close to US $1.9 billion to develop Debian 2.2 as proprietary software.[106] While such estimates are hard to evaluate, in free software circles and FOSS conferences I attended, I have often heard such numbers circulated and hyped, attesting to the need of many FOSS developers and project leaders to be able to measure themselves up against the proprietary alternatives.

A different reason for the wide diversity in distributions is spurred by different actors' interpretation and understanding of what the target market is. One of the most recent Debian-based Linux distros, Ubuntu, for example, is a case in point. Ubuntu, which in Zulu means "humanity towards others," is distributed under the tag line "Linux for Human Beings." A young South-African entrepreneur named Mark Shuttleworth started Ubuntu in 2004, with the explicit purpose of bringing Linux to the desktop and to the masses. Shortly before that, Shuttleworth had made a fortune by selling his Internet security start-up to software giant Verisign. As part of his quest for new challenges Shuttleworth bought himself a ticket to the International space station on board a Russian spacecraft for US $20 million, but apparently the sky was not his limit. Coming from poor Africa, Shuttleworth claims he is interested in giving others the opportunities that he had, and the best way that he knows is by giving people access to tools, primarily software.[107] He noticed that Linux had gone a long way in

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[106] J. M. Gonzalez-Barahona et al., "Counting Potatoes: The Size of Debian 2.2," *Upgrade Magazine* II, no. 6 (2001).
[107] Fred Turner notes how similar language was used in the Whole Earth Catalog, who used the moto of 'access to tools'. See Turner, *From Counterculture to Cyberculture : Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*, Ch. 3.

the server market but was relatively unknown in the mass market. Ubuntu, Shuttleworthe explained to a group of developers in a recent conference that I attended, can change this. In a recent blog post he repeats this mantra:

> As a community, we've done amazingly well in terms of challenging the historical epicenter of computing - the supercomputer and data center - and driving change there. Linux now represents a healthy and growing share of infrastructure in large organisations globally. Apache and other infrastructural components have established the new de facto standard for software in the back office: freedom. It would be easy to declare victory. But, as anybody who flies in the backseat of a military plane to land on a carrier and declare victory will tell you, it would be premature. The real challenge lies ahead - taking free software to the mass market, to your grandparents, to your nieces and nephews, to your friends. This is the next wave, and if we are to be successful we need to articulate the audacious goals clearly and loudly - because that's how the community process works best.[108]

In order to achieve these goals, Ubuntu focuses on developing end-user application and puts extra attention on usability and user experience, all as part of an effort to 'make Linux beautiful.' One of the other unique aspects about Ubuntu is its distribution model. Like other distros Ubuntu can install from a single CD, but to ensure that copies of Ubuntu are not hoarded by middlemen, as might be the case in poor countries where the cost of the media can be significant, Shuttleworth developed the concept of the 'freedom toaster', a CD burning device that is installed in public places throughout the developing world and which allows users that come with an empty writable CD to burn for themselves a copy of Ubuntu. In that way anyone with an empty CD can get a copy, and enjoy the power of free software (of course they would later need a PC to run it.) Ubuntu represents one of the most successful attempts to bring Linux and free software to the masses. Estimates on the amount of

[108] Mark Shuttleworth, *Blog Entry: Big Challenges for the Free Software Community* [Web] (October 20th 2006 [cited November 14th 2006]); available from http://www.markshuttleworth.com/archives/62.

Ubuntu users vary widely, but most would agree that there are at least a few million users so far, and that Ubuntu's user base and developer base is rapidly growing.

Despite attempts like Ubuntu's, FOSS's greatest achievement is not in the end-user and application space where Microsoft still dominates the market almost completely with Windows™ and Office™, but rather in the server and internet infrastructure space. The most clear, and oft-cited, example for this is Apache, a server system that powers Internet websites. Open source advocates often use Apache as a poster-child example, mainly due to the rapidity with which it overtook the server market. Merely two years after it was invented and developed by a group of volunteers, Apache became the webserver of choice for more that 50% of all Internet websites, without any coordinated marketing effort.[109] (Figure 3-2) Apache was developed from an early version of code released to the public domain by the National Center for Supercomputing Applications (NCSA). It soon surpassed Sun Microsystem's server and now splits the market mainly with Microsoft's Internet Information Server (IIS).

[109] Brian Behlendorf interview.

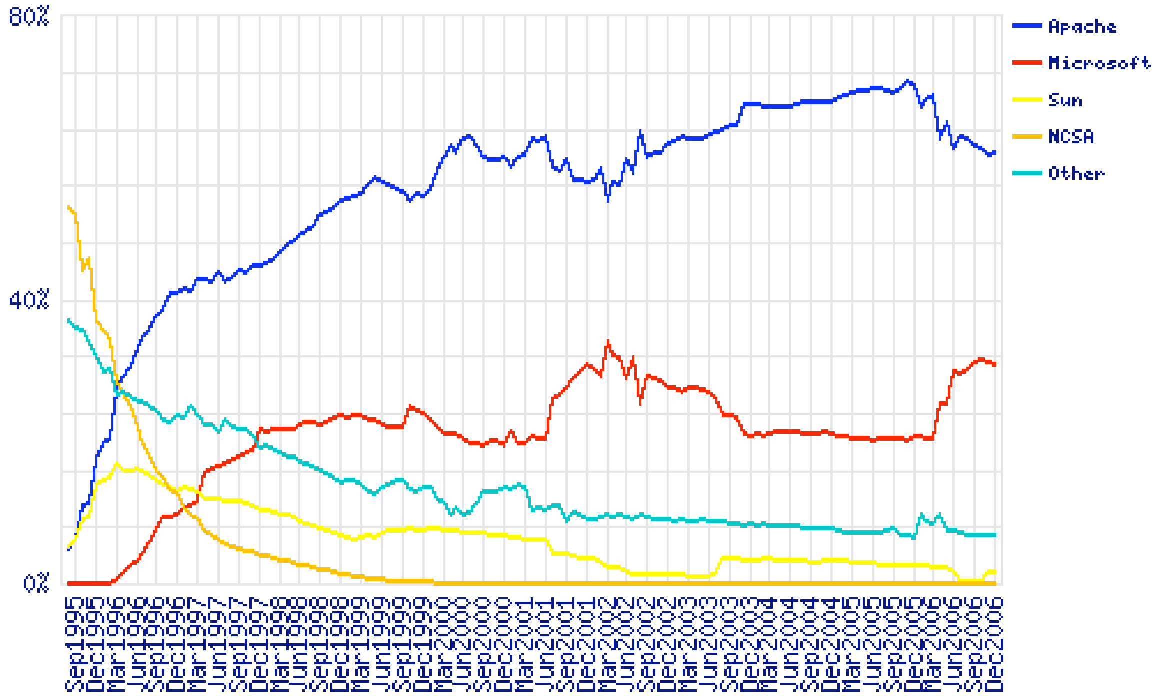

Figure 3-2: Market Share for web servers (August 1995 - December 2006)[110]

What is notable about Apache is that it can command such high market share without commercial backing despite the fact that the webserver is a fundamental technology to any online business. The same cannot be said about end-user applications. There remains the conundrum concerning the disparity between FOSS's high adoption rate in the server/infrastructure market and its relatively low adoption rate in the desktop space where it only occupies a few percent of the entire market. The common explanation that I have heard from people in the field is that FOSS developers have modeled the users after themselves, and the techy-geeky types that they are, they have historically prioritized infrastructure development over application development. Reversing this situation seems to be the guiding principle in distros like

[110] Source:Netcraft, *Web Server Survey* ([cited 12/04/08]). The fluctuations in market share are triggered mainly by new version of IIS that hit the market every few years.

Ubuntu. It took many years to develop the basic elements like reliable programming languages, Internet web-servers, web-browsers, etc., various FOSS developers point out. Now it's time to develop the applications that sit on top of this infrastructure say people like Shuttleworth. An apocryphal joke in the FOSS world claims that the first time FOSS developers developed presentation software was when FOSS became big business and FOSS advocates needed to create slide-shows for investors who have been accustomed to the visual style of Microsoft's PowerPoint. Regardless of this joke's validity, this situation is rapidly changing as is evident from a quick look at SourceForge.net, the world's largest clearinghouse for FOSS projects.

Owned by VA Software, the company that I discussed earlier, SourceForge.net is the world's largest portal for Open Source software development. It provides free hosting for more than 137,000 FOSS projects and boasts over 1,450,000 registered users.[111] (December 2006). SourcForge offers resources for managing software projects that include: (a) software version control tools; (b) distribution tools for both binary files and source code; (c) space for documentation; and (d) tools for tracking issues and bugs related to the software. The projects on SourceForge are divided into categories and topics that span a wide spectrum that includes, for example, software development tools, enterprise customer relationship management software, scientific applications, as well as games and file-sharing programs. The following table summarizes the recent distribution of SourceForge projects into topics:

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[111] *Sourceforge.Net Hompage* [Web] (December 25th 2006 [cited December 20th 2006]); available from http://www.sourceforge.net.

Table 3-1: SourceForge FOSS Projects By Topic, December 2006[112]

Topic	Number of projects
Software Development	25178
Games	15460
Multimedia	14032
Database	6349
Networking	4740
System Administration	3414
Desktop	3402
Security	3008
Storage	2328
Financial	1945
Hardware	1709
Enterprise	1706
Clustering	461
Voice Over Internet Protocol (VoIP)	368

The variety of software available on SourceForge is astounding. Clearly projects that relate to software development, database management, and networking are very popular, but equally --if not more so-- are projects that relate to gaming, multimedia and desktop applications. This suggests that there is a wide diversity of interests within the FOSS community and that unlike the situation several years ago when FOSS consisted of a small set of tools for software developers, today ample attention is given to end-user applications. The most downloaded software projects on SourceForge are all in the application space, with peer-2-peer client applications like *eMule* at the top with over 270,000,000 downloads.

[112] *Sourceforge.Net Software Map* ([cited 12/04/08]). Note: each project can fit into more than one topic.

The technical design of SourceForge encapsulates the FOSS development model. Each project on SourceForge is tagged with information that designates its level of maturity and activity. Anybody can register on SourceForge, for free, and start a new project. New projects start in status ‘alpha’ and often have a single or a mere few developers to support them. At that stage a project is usually just an idea, or an early prototype and is, in essence, not a software project but a call for collaboration. A developer that starts a project becomes a self appointed project-administrator. If the project garners interest in the community, with the project administrator’s permission, other developers can join and together they start designing the software. When there is a basic understanding of what the project’s objectives are, developers can start writing the code collaboratively, each working on self-appointed tasks. The project admin can allow other developers to become admins as well. If the project reaches a working version stage, it becomes a ‘beta’ project. Even before that it can use SourceForge’s infrastructure to start distributing files and managing the source code. Only about half the projects ever get to the stage of having any working version to distribute.[113] The other half is abandoned mid-way. A successful project can thus advance through a few more stages until it reaches the category named ‘production/stable’. At that point development focuses on bug-fixing and future versions. There are now over 20,000 ‘stable’ projects available on SourceForge. While the dominant terminology on SourceForge is that of ‘open source’, a plurality of these projects (just over fifty percent) is distributed under the terms of Stallman’s General Public License, and is thus strictly free software.[114] SourceForge, therefore, is the world’s largest repository

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[113] Statistics on this and the following paragraphs were generated using SourceForge.net’s built in advanced search tool.
[114] For a detailed analysis of license breakdown and an explanation of developer choices see Michal Tsur and Shay David, *A License to Kill (Innovation)? Open Source Licenses and Their Implications for Innovation (Paper Presented at Harvad's Berkman Center Cyberscholar Lecture Series)* [Web] (April 30th 2005 [cited December 26th 2006]); available from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=858104.

of free software. Almost exclusively the software on SourceForge is available for download free of charge, usually in both source and binary form, bringing to the fore once more the double meaning of the 'free' aspect of FOSS.

SourceForge can thus be understood as an outlet that enables people with diverse motivations to participate in the creation of software collaboratively, without having to agree on one goal or one motivation. It also allows businesses and private projects to exist simultaneously. My survey of SourceForge is consistent with the literature reviewed in Chapter 2, primarily Rishab Ghosh and Paul David's empirical studies of open source communities.[115] The clear conclusion is that many FOSS developers now find a living by writing FOSS code, but they do it in a way that is consistent with their beliefs about how users' rights should be maintained.

A common attitude I often encountered within these communities, especially from people like Jon Hall, Bob Young, or Mark Shuttleworth who have made a fortune in consulting or by selling their companies, is that there is no contradiction between 'doing well and doing good'. Some developers feel privileged that they can promote free software while there are people willing to pay them to do it. SourceForge, for example, is a good place for developers to find jobs using a special bulletin board and marketplace for services that it maintains just for this purpose. Many developers thus perceive SourceForge as a successful attempt at combining the FOSS philosophy with the market economy. In Chapter 6 where I discuss BIOS's adaptation of the FOSS model to biology, I will show how the creation of BioForge, the biological counterpart of SourceForge is at the center of the attempt to adapt the open source model to biology.

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[115] See David, Waterman, and Arora, *Floss-Us - the Free/Libre/Open Source Software Survey for 2003* ([cited 12/04/08]), Ghosh, "Understanding Free Software Developers: Findings from the Floss Study.", Ghosh and David, *The Nature and Composition of the Linux Kernel Developer Community: A Dynamic Analysis* ([cited 12/04/08]).

Levels of participation in FOSS projects

On the face of it, FOSS embraces a form of "radical inclusiveness" as some actors call it.[116] On sites like SourceForge.net, anyone with an email account and basic language skills can participate regardless of age, race, class, gender, past credentials, employment history, institutional affiliation, level of education, geographic location, lineage, or other factors that in a traditional systems would serve as gate-keeping barriers to inclusiveness. Clearly, however, I need to qualify what is meant by participation here. Inclusiveness in the software development process starts with modes of participation that are often neglected, and the most basic of these is observation, which in this context translates to reading the mailing lists and occasionally posting to them.[117] As the Linux kernel developed, for example, there were tens of thousands of readers on the Linux Kernel mailing list. It's hard to estimate the exact number since 'lurking' leaves little trace, but secondary evidence suggests that "non-active" readers were abundant. A developer named Zack Brown, noticed this and started a weekly newsletter called *Kernel Traffic*, which summarized the mailing list's key threads of discussion. The need for such a weekly newsletter arose from the sheer volume of traffic on the Linux Kernel mailing list that grew from 3,000-4,000 messages per week in 1999 to about 15,000 messages per week in 2005.[118] Kernel Traffic became a summary newsletter that allowed bystanders to get updated summaries of key discussions. Soon enough *Kernel Traffic* itself became a phenomenon and Brown often received fan-mail from readers that wanted to thank him for his important contribution. It is only through such interactions that these "silent readers" can be observed. It is important to note that this social sphere should

[116] Brian Behlendorf interview.
[117] One can argue that the basic level of participation is simply 'use of the end product', which might be true in some context, but for clarity in the following analysis we take as the relevant social group to be those that actually participate in the development process.
[118] Zack Brown interview

not be viewed as external to the development process, but rather as essential parts of it; it is this social circle that is often the feeder for more engaged participation and it is through this activity of observation that newcomers can be acculturated.

In that sense, the classic economic ‘free rider’ problem is a false problem.[119] Not only do ‘lurkers’ not take away anything from other participants, they actually add value by the very fact that they become an audience for the ‘public’ proceedings that are going on the mailing lists. In addition there is a chance that ‘lurkers’ would move closer to the core of development, and move to enhanced levels of participation.

The second level of participation is bug reporting, which is an essential part of any software development project. As it pertains to debugging, the meanings of participation and collaboration are intertwined. Collaborative debugging works at two levels: (1) what is hidden from the eyes of one programmer or software designer is evident in the eyes of another; people can find programmatic errors just by looking at the “source code” that other people wrote; (2) by releasing many versions of the product as *early* as possible testing is done in the real-world and not in simulated environments—this guarantees that as many external and environmental variables are internalized since what constitutes a far-fetched operation scenario for one person is the everyday state of affairs for another. Bug reporting happens using special Internet-based bug tracking software like the popular *Bugzilla*.[120] Each bug report consists of a

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[119] Economists are fascinated by ‘free riding’, situations in which only a few contribute and many enjoy the fruits of their labor. Classic economics predicts that under such circumstances the motivation for participation will diminish over time, but evidently in many cases it does not. Perens suggests that in the context of FOSS, the whole problem is misstated. See Bruce Perens, "The Emerging Economic Paradigm of Open Source," *First Monday* 9, no. 10 (2005).

[120] *Bugzilla* is a pun on the name *Mozilla*, the name of the organization that maintains the source code for the web browsers that resulted from Netscape’s code release in 1998. Mozilla itself is a combination of the name *Mosaic*, the name of the first NCSA browser on which Netscape’s *Navigator* browser was based, and *Godzilla*, the fictional Japanese monster, which is known for its huge size. It is common for FOSS projects to have playful names like these, alluding to either popular culture or earlier versions of software (both proprietary or FOSS) from which they take inspiration. The naming conventions reflect the culture of appropriation and the deep-rooted philosophy that no project stands alone and that any FOSS project is based on earlier projects and might be the basis for future projects.

description of the problems, the software environment in which it occurred, and details on how to reproduce the bug. Once a bug report has been submitted, users can rate its severity and post comments affirming and explaining it. Often a lively discussion thread begins among participants, sharing information about the bug and its outcomes and debating its status. When code maintainers and developers (which are part of increased levels of participation as discussed below) fix a bug, they 'close' it in the system, but often the bug is 're-opened' since in other environments the software still malfunctions. At other times a bug can be 're-opened' because there is a fine line between bugs and features. Often, especially given the common lack of design documentation, it is not clear what the expected functionality is, and when the software performs as designed vis-à-vis situations in which it actually malfunctions. In these situations the lines between 'bug reporters', 'maintainers' and 'developers' are blurred, and developers get a chance to reflect on their system of self-governance and authority. This happens not only on bug tracking systems but also on mailing lists and chat rooms. As Coleman argues in on her study of the Debian community, in situations where technical debates ensue on such forums, "developers explicitly raise issues of authority and renegotiate the lines between democracy, consensus, and meritocracy that define their system of governance."[121] Thus, bug reporting is an activity through which newcomers can also socialize with more experienced developers and gain insights regarding a community's inner working.

The third level of participation is documenting, done by documenters. Despite wide agreement in the technical community that documenting source code while coding is better than documenting it after the fact, some programmers are notorious for producing code without comments. For newcomers, however, this represents an

[121] Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition", Ch.7, 29.

opportunity for learning; documenting someone else's code is a good way to learn how a project works. It has become a custom, therefore, for newcomers to start by documenting the code. Documentation can work at two levels: (1) writing user manuals, release notes, usage examples, manual entries, etc; and (2) writing in-code comments. The first degree of documentation requires less inclusion as it does not require submission of code to the central repository. The second level of documentation involves the rituals of actually changing text annotations within source code files, and requires the documenter to connect to source files on the project's central version control system. As such it is only one step removed from actually changing the source code itself.

The fourth level of participation is bug fixing done by patchers. The premise in this environment is that 'every bug is shallow'. If there is an error it will be spotted sooner or later. The more people who can test the software and fix problems, the faster the problems will be fixed. A bug fix can be trivial or profound. Bug fixing is an activity that is performed by people with an intermediate level of inclusion. They have to know enough about the project to know that there is a malfunction and how to fix it. They have to have an interest, whether self-motivated or not, to spend the time necessary to fix it. As Kelty points out, "debugging" is an elastic term that can mean: "reading someone else's code and helping them understand why it does not work; it can mean finding bugs in someone else's software or it can mean reliably reproducing bugs; it can mean pinpointing the cause of the bug in the source code, or it can mean changing the source to eliminate the bug, or it can, at the limit, mean changing the software to do something different or (in the debugger's eyes) better"[122] Surprisingly to an outsider, perhaps, debugging takes more resources than designing the software or

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[122] Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*, 242.

coding it. My own experience, like that of many other developers I talked to, shows that in traditional software projects, debugging can consume 90% or more of the time and budget of a medium or large software project. It is not surprising, therefore, that at this level of participation rests one of the key differences between FOSS and proprietary software development. Whereas in proprietary software development debugging is assigned only to the programmers or quality assurance tools, in FOSS debugging becomes a participatory activity.

The fifth level of participation is feature contribution done by project maintainers. The lines between debugging and feature contribution are obviously blurry. Maintainers are the people who develop features that make up the majority of a software project's functionality. Features can include enhancement of functionality, adaptation to different working environments, development of auxiliary tools, etc. To become a maintainer, a programmer has to have a high level of inclusion, to have a good understanding of how the project works, and to have working relationship with the other programmers on the team, so that code changes remain coordinated. From a technical standpoint, maintainers must have access rights to the code versioning system. On SourceForge, the project administrator can grant such access rights.

The sixth and inner most level is core development. At this level the heart of the software project is actually written. This task is entrusted to the project administrator and his helpers. In many cases the first core developer is the person (or small group of people) who first start a FOSS project.[123] In large projects, however, the amount of core developers can grow significantly, and for the largest projects, like Linux itself, it must grow, otherwise it would become unmanageable. The following table, for example, shows the amount of code in major Linux kernel versions.

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[123] David, Waterman, and Arora, *Floss-Us - the Free/Libre/Open Source Software Survey for 2003* ([cited 12/04/08]).

Table 2-2: Size of Linux Kernel Versions 1991-2003[124]

Date	Linux Version	Number of lines of code
September 1991	0.01	10,239
March 14, 1994	1.0.0	176,250
March 1995	1.2.0	310,950
January 25, 1999	2.2.0	1,800,847
January 4, 2001	2.4.0	3,377,902
December 17, 2003	2.6.0	5,929,913

Clearly after the first few years Torvalds needed help in managing the kernel development and maintenance, and an organic system of 'lieutenants' developed. Importantly, Torvalds did not select his lieutenants, the community did. To understand how this can happen, it's important to realize that any large enough software project is divided into modules and packages. This division into modules induces a social structure of small groups of developers that work closely together. As a recent study of the composition of the Linux kernel found, unlike naïve descriptions of FOSS as a site for massive collaboration, in actuality most FOSS is developed in small groups that sometimes include only a handful of programmers.[125] Collaboration reaches large scale when the works of these groups are combined and when developers migrate from one group to another, but within each group a tight social structure allows leaders to rise from the bottom up. In a recent interview, Torvalds explains:

Q: How do you pick the core kernel contributors. How many are there?

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[124] Source for data: Wikipedia: Linux_Kernel

[125] Ghosh and David, *The Nature and Composition of the Linux Kernel Developer Community: A Dynamic Analysis* ([cited 12/04/08]).

> A: The lieutenants get picked. It's not me or any other leader who picks them. The programmers are very good at selecting leaders. There's no process for making somebody a lieutenant. But somebody who gets things done, shows good taste, and has good qualities -- people just start sending them suggestions and patches. I didn't design it this way. This happens because this is the way people work. It's very natural.[126]

Clearly, what is natural for Torvalds depends on a very specific technical setting. Selecting lieutenants is not the only practice that exhibits a sort of emergent order; a similar order needs to exist at the basic practices of making daily changes to the code. Code contribution is coordinated using special software called a Concurrent Versioning System, or CVS. Each software project is made up of many files that have to be compiled or run together. The objective of the CVS system is to ensure that the files remain compatible with one another as the system is developed. There are two primary ways to ensure that this happens: (1) to allow individuals to lock certain files while they are working on them, and thus serialize part of the job; or (2) to allow parallel editing, and then worry about merging conflicts if and when they arise. In contrast to the lock-out system espoused by Microsoft's CVS system, SourceSafe™, the CVS software used in FOSS projects, *CVS* and *Subversion*,[127] use the second principle. They allow concurrent editing, requiring a clear set of rules and a strict social order to coordinate contribution. If anyone with access permissions to CVS can make changes to the code, who decides what takes priority? The same question is raised for the outer layers too; who decides what features to develop? what bugs to fix? what manuals to write? As noted in Chater 2, in his book, *Two Bits*, Chris Kelty investigated these and other questions that pertain to coordination in FOSS projects finding that often the answers are resolved by way of trial and error. Often the

[126] Hamm, *Linus Torvalds' Benevolent Dictatorship* ([cited 12/04/08]).
[127] 'Subversion', a FOSS project in itself, is yet another example of a playful name for a project. The whole objective of a source control system is to maintain coordination, but as the name suggests, it could be easily subverted as anyone can take the code and fork from it.

developers do not know a priori what should be included in the software and how to develop it. The answers become clear as the project develops, and, as Kelty argues, it is highly dependent on the specific context. He writes:

> Experiments in coordination in Free Software are highly contextualized; they emerge out of a concrete infrastructure. The successful forms of source code sharing in UNIX, the concept of open systems and the Free Software copyright licenses all lend constraint to the forms of coordination that occur in any given project. Coordinating people is also about coordinating code—and vice versa. As these experiments unfold, as the participants figure out what they are trying to achieve, as they are replicated and normalized, they become in turn practices available for modulation.[128]

What happens when conflicts inevitably ensue? In her dissertation that I reviewed in Chapter 2, Coleman found that "the normative ideal for technical decision making is a process of open-ended technical argumentation, where the process of debate, conducted over mailing lists, bug reports, and IRC channels, ideally clarifies the right solution and leads to enough 'rough consensus' to proceed."[129] This consensus-seeking practice highlights the fact that democratic voting that would ostensibly be a simple solution for differences in opinion is treated with suspicion because it obscures the potential for subduing the opinions of a large minority. What happens if such a consensus does not emerge? In those cases the leaders of the project often have the last word, and the community trusts them to make wise choices. In the case of Linux, Torvalds had served as an official leader for the past 15 years, earning himself the oxymoronic title of 'benevolent dictator'. The title is taken only half seriously, but is widespread enough to warrant its own Wikipedia entry.[130] When asked in an interview about his governing style and whether he is indeed a dictator Torvalds says:

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[128] Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*, 268.
[129] Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition", Ch. 7, p. 8.
[130] Wikipedia: benevolent_dictator

> To be honest, the fact that people trust you gives you a lot of power over people. Having another person's trust is more powerful than all other management techniques put together. I have no legal or explicit power. I only have the power of having people's trust -- but that's a lot of power. I am a dictator, but it's the right kind of dictatorship. I can't really do anything that screws people over. The benevolence is built in. I can't be nasty. If my baser instincts took hold, they wouldn't trust me, and they wouldn't work with me anymore. I'm not so much a leader, I'm more of a shepherd. Now all the kernel developers will read that and say, "He's comparing us to sheep." It's more like herding cats.[131]

Not everybody agrees with Torvalds and the other 'benevolent dictators' who are influential leaders of large FOSS projects. Under the surface there is often subtle fear from the abuse of power. It is not uncommon to hear developers mention half-jokingly a fictitious 'cabal' that makes secret decisions about a project's direction. Coleman found that:

> If democratic rule is sometimes treated with overt suspicion and dislike, there is a far more subtle fear concerning the importance of meritocracy and the meritocrats it produces; namely, the fear of corruption. Specifically, there is discomfort in the idea that the technical guardians could (as they are vested to do) exercise their authority without consulting the project as a whole and thus foreclose precisely the neutral, technical debate that allowed them to gain their authority in the first place.[132]

Surveying these different levels of participation the structure that emerges is onion-like. Moving from internal to external rings shows larger numbers of peoples with fewer levels of inclusion, but inclusion nonetheless.[133] Alternatively, FOSS can

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[131] Hamm, *Linus Torvalds' Benevolent Dictatorship* ([cited 12/04/08]).
[132] Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition", Ch. 7, p. 8.
[133] When discussing this model, Larry Wall, the originator of Perl, an open source scripting language finds that "most people see the outside of the onion, not the inside. Unless they make onion rings. But even then, the bigger rings have more to them than the smaller rings. Let that be a lesson to those of you who wish to be "inner ringers." That's not where the real power is. Not in this movement, anyway." See Larry Wall, "Diligence, Patience, and Humility," in *Open Sources: Voices from the Computer Revolution*, ed. Chris DiBona, Sam Ockman, and Mark Stone (Beijing: O'Reilly Associates, 1999).

be seen as consisting of a ‘long tail’ of participation: while contribution might be divided according to a power law distribution with the core developers contributing the majority of the code, small contributions from the outer layers add up and are essential to a FOSS project’s well being.

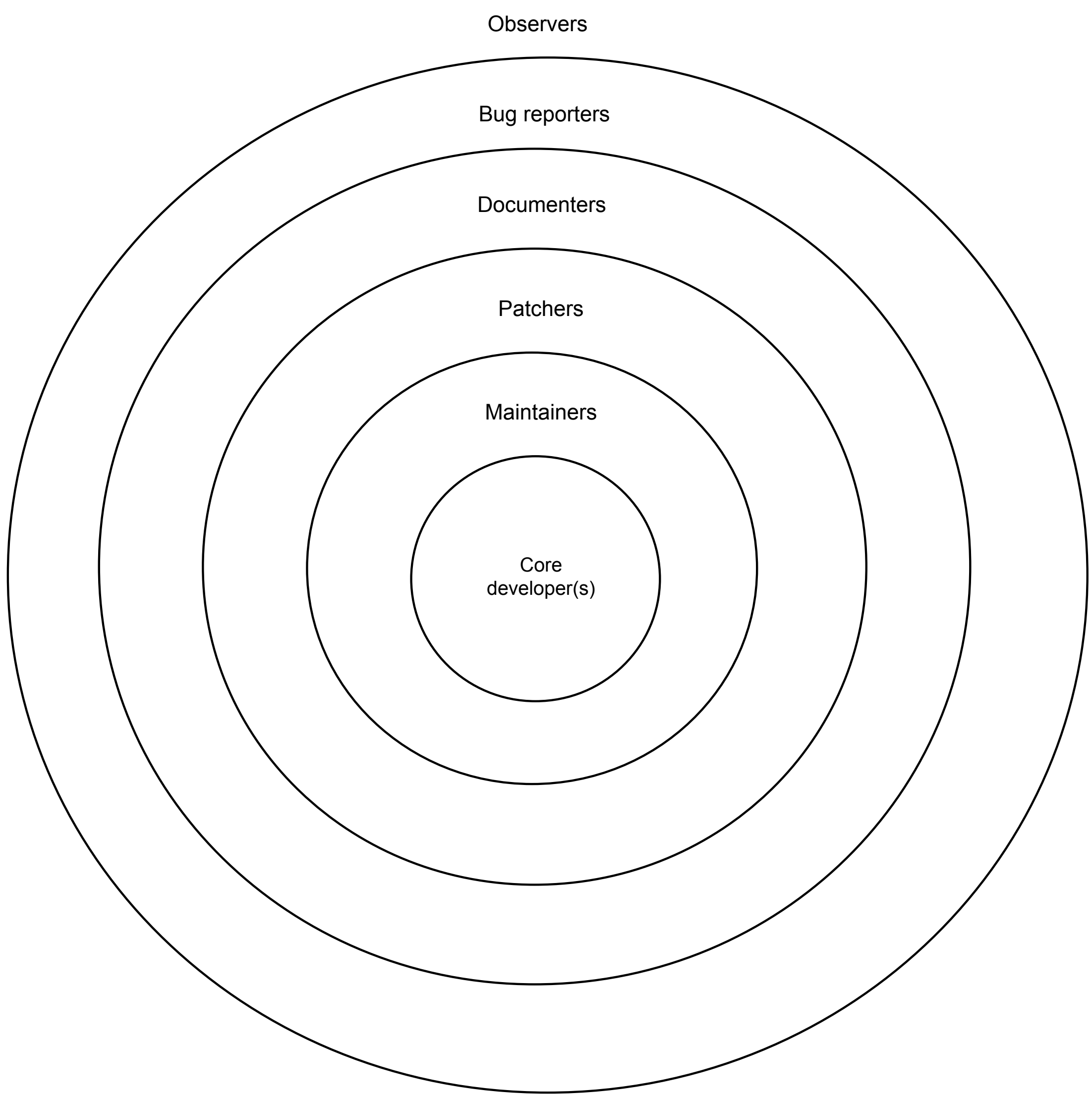

Figure 3-3: The FOSS Software Development ‘Onion Model’

It is important to stress that these analytic divisions between level of participation are clean only on paper. In actuality participants change roles all the time, and also have different roles in different projects to which they contribute. In his Ph.D. dissertation Nicolas Ducheneaut investigated the ways in which open source communities are reproduced, transformed and extended through the progressive integration of new members. He looked at both the social and material aspects of open source projects and analyzed participants' varying degrees of contribution. What Ducheneaut found was that users tended to change their roles as a result of their individual learning as well as political processes. He describes a typical scenario:

> Through an initial period of observation, newcomers first assimilate the norms and values of the community and analyze the activity of the experts. Early contributions should be modest but useful to the project: identifying important bugs and simultaneously proposing possible ways to fix them is a good way of introducing oneself.…If and when a participant has contributed enough bugs and solutions, he will eventually be granted [Concurrent Versioning System] CVS access so that he can submit his modifications without review. To evolve any further, participants have to start building an identity for themselves and become more visible to the core members. Once a participant is given the right to craft material artifacts (through direct access to the CVS database), he then has to demonstrate a higher level of mastery by taking charge of a sub-module of the project he wants to keep evolving. The output of the work on this module is evaluated during a rite of passage, where the entire community scrutinizes what has been produced and the core members finally deliver a verdict of acceptance or rejection…Eventually, if the work of the participant is finally integrated into the project's architecture after the rite of passage above, another step has been taken: the participant is now a developer.[134]

Clearly significant differences arise in different FOSS projects concerning the ways in which these different tasks are allocated and coordinated. Within the realm of

[134] Nicolas Ducheneaut, "The Reproduction of Open Source Software Programming Communities" (PhD Dissertation, University of California, Berkeley, 2003), 187.

FOSS some projects are more Cathedral like and some are more Bazaar like. The social structure is highly enmeshed within technical practices, and is highly dependent on the personality of the project leaders. In Chapter 7, I will discuss this in greater detail and explore the changes that these structures have for the notion of expertise.

Conclusion

Let me summarize, and set the ground for the following chapters. I began this chapter by looking at how over a two-decade history, what started as Stallman's one-man-show in 1984 turned into a huge software repository and widely spread framework for software development and distribution, used by both businesses and individuals the world over. The combination of Stallman's zeal and legal acumen with Torvalds's pragmatism and innovative project management methodology resulted in a foundation that allowed a community to flourish around them, and to many other hackers to contribute their talent, skill, and time. The end result is a set of projects that are changing the computer sector profoundly. The morphing of Stallman's 'free software' into the business-friendly 'open source' was in itself a process of re-interpretation and re-definition of the meaning of free software, similar to the meaning-making process that had brought Stallman and Torvalds to invent their operating systems to begin with. This process raises an important question for S&TS concerning the notion of closure, which I will return to in the following chapters as well. Can open source be closed? Can a system that encourages participants to reinterpret its artifacts, to appropriate them, to change them, to morph them, ever stabilize? Are some of the dynamics I observed specific only to software, or do they have parallels in other domains too? I shall leave these questions open, until in the next few chapters I investigate several other systems.

It is time to return, however, to Kelty definition of 'recursive publics' that I quoted in Chapter 2. Kelty argues that a recursive public is "vitally concerned with the material and practical maintenance and modification of the very means of its own existence as a public, as a collective independent of other forms of constituted power."[135] In the story of FOSS and my investigation of the modes of community participation this recursion clearly comes to bear. The community's openness to volunteer participation creates a framework in which the technological, legal, social, and economic structures are oriented towards empowering users and establishing freedoms of various sorts, whether those are personal, technical, or political. Freedom and openness, which are embedded in legal and technical means, are, in a recursive way, what keeps these communities vitally concerned with the very maintenance of themselves as such open communities. As also noted in Chapter 2, Lessig's model of norms, law, markets, and code[136] can help us understands how the four categories constitute regulatory regimes that influence the behavior and freedoms of individuals within such communities. Law, norms, market forces, and code (technical architecture) work together in FOSS to regulate the things that the programmers and users of the software can do. In Lessig's view, we, as a society, should understand those interactions and intervene in them if we want to create a more equitable and just society. Before I can make any such claims, however, the following two chapters will add a deeper historical dimension to my work. Clearly FOSS rests on a long history of participation and collaboration among users that have for many years existed outside of mainstream industry. Particularly, I see in FOSS a recent incarnation of a deep-rooted tradition of hobbyists and amateurs who challenge an established technological

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[135] Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*, 2.
[136] Lessig, *Code and Other Laws of Cyberspace*.

order. As Haring points out, FOSS can be read in direct relationship to earlier hobbyist culture:

> Whether serving as leaders or provocateurs, hobbyists demonstrated diverse options for technical culture. Hobbyists engaged with technology in a way that was fun, collaborative, educational, intense, and creative. These methods and values were independent from, and at times in direct conflict with, the technical culture of profit-driven production. … A cooperative spirit persists today in open-source development, in the legitimate distribution of free software, and in cavalier attitudes toward the illegitimate copying of proprietary software. This spirit is a legacy of hobbyists and a reminder that there exist alternative ways of using and relating to technology.[137]

Haring's study of radio ham culture in the second part of the twentieth century shows that many of the practices of sharing, collaboration and participation that can be seen in FOSS today exist in that other culture too. In the first part of Chapter 4, I will make some of those links explicit, as I explore the early days of ham radio. At the end of Chapter 4, I revisit some of the theoretical issues I tackled here.

I have chosen FOSS as the longest, and primary case study in my work since I believe it best represents the overall argument of my work and allows me to identify the key elements that will reoccur in the other case studies as well, which include the following:

- The tension between radical inclusion and hierarchal control as social structure is changing. As I have shown, communities of volunteers working together on a joint project are the dominant social form in FOSS. These communities are defined to a large degree by the way they address the problem of social scale. I presented the onion model which shows how there is an architecture of participation that allows different people to participate in the system at different levels. This model shows how FOSS represents a new mode of hierarchy, that is often based on merit and

[137] Haring, *Ham Radio's Technical Culture*, 17-8.

skill and not on formal modes of accreditation. FOSS is different from managerial firms and from price-based markets in the way that it handles the assignment and selection of tasks, but it is similar to them in the sense that FOSS too has decision making processes, that some actors have more power than others, and that some are in the center and some in the periphery. In the following chapters I will show that each of the systems investigated addresses this tension in a slightly different way. BIOS tries to replicate the norms and modes of regulation from FOSS. The ARRL does it by creating a central skeleton of control embodied in the structure of national Trunk Lines, but leaves a lot of room for self-selection and improvisation at the single relay station level. The GOC, the most hierarchical of all systems, relies on military models of organization with regional managers and staffing objectives. The way that the systems open up to volunteer participation and the way that they manage it becomes a dominant characteristic.

- The tensions between competing notions of freedom and between volunteer organizations and commercial interests. FOSS shows how in systems that are open to volunteer participation multiple notions of volunteerism, openness, and freedom collide. On one hand, people like Stallman go out of their way to ensure that freedom is maintained in the meaning of free speech and not free beer. On the other hand some commercial companies like IBM and Sun find FOSS to be a source of cheap labor. This tension between these two approaches is best represented by the story about the changing of the name from free software to open source with the expressed objective of trying to reconcile those two competing interpretations. Likewise, the evidence that over 50% of the participants earn money from their FOSS activities complicates the notion that systems like FOSS are operating in the non-market, as Benkler calls it. In the following case studies too, I will discuss several incidents in which competing meanings of volunteerism and freedom collide. In the case of the ARRL this happens in the positioning of the league at one and the same time as a protector of the public good and a valuable communication mechanism in cases of emergency that hold military and commercial value. In the case of BIOS this tension is apparent in the duality of the system as both an entry ticket for large industrial players into the biotechnological arms race and as a democratic, open stack of technologies aimed at relieving the problems of the world's poor. In the case of the GOC, I will show how participants from within the system raised these very issues with the GOC command, suggesting that if the task they were asked to perform was of national importance they should be compensated for their time.

- The changing notions of property and the alternative ways to protect and regulate it. FOSS brings to the foreground many of the issues that come up when moving from physical property to intellectual property. I showed how some actors, like Stallman or Moglen, suggest that the very term 'intellectual property' already assumes to much, and should be avoided in the context of software, which can be replicated at zero marginal cost while undermining the idea of scarcity, one of the foundations of thought about property within the frame of neo-liberal economics. For this reason Stallman and Moglen created the concept of copylefting, which reverses the intellectual property system on its head. In the case of the ARRL, this tension takes a different form, when the contested resource is not the outcome of the system, but rather the airwaves, its field of operation. There too, the notion that a new mode of regulation is necessary becomes evident. In the case of BIOS, the issue is complicated even further, as patents, which are the strongest form of protection, protect the property that is being debated.

Chapter 3, thus, sets the ground for the rest of the work, identifying the key theoretical components and outlining the structure for the following case studies, which will each explore these ideas further. My argument will be developed in each of the following chapters, to show how these tensions take on different forms. Chapter 7 will return to this discussion in the context of openness as an ideology.

CHAPTER 4:

THE AMERICAN RADIO RELAY LEAGUE –

COLLABORATION AND REGULATION IN THE EARLY DAYS OF RADIO

> It is now possible for the private citizen to communicate across great distances without the aid of either the government or a corporation…the organization of the relay league actually marks the beginning of a new epoch in the interchanges of information and the transmission of messages.
>
> Advertisement in *Popular Mechanics*, July 1914[1]

Introduction

This chapter tells the story of the American Radio Relay League (ARRL), a volunteer organization that was established in 1914 and that within months of its inception built a distributed, continental-scale radio relay network, which spanned the entire United States. Using store-and-forward techniques, ARRL volunteers were able to transfer Morse-code messages over radiotelegraphs across the country in record speeds. The ARRL was thus the first grassroots, coast-to-coast free communication network in the United States, preceding by almost a century the Internet peer-to-peer networks like Skype, which would boast similar claims-to-fame a hundred years later. This relay network was based completely on collaboration amongst 'hams' (radio amateurs) that volunteered their free time and personal radio equipment, demonstrating the strength of volunteer power even to the most disapproving skeptics. Moreover, the work of these volunteers involved technological and organizational feats, like conveying messages from coast to coast and back in just over an hour,

[1] Quoted in Clinton B. DeSoto, *200 Meters & Down - the Story of Amateur Radio* (Hartford, CT: American Radio Relay League Publishing, 1936), 40.

rivaling in quality and efficiency the contemporaneous, centralized, proprietary, and controlled networks operated by the military and AT&T in the early 1920s.

In this case study I explore a system that motivated participants with non-monetary incentives, that built an alternative model of labor organization, and that provided proof for the feasibility of large-scale, distributed, participatory technological collaborations. Like in the other case studies, throughout this chapter I will expand on the three themes of this work: (1) explaining how a specific volunteer community that was open to massive participation developed in its historical context; (2) expanding SCOT to accommodate this multi-sited, networked system; and (3) investigate the meaning that the ARRL had (and still has) for democratic culture.

First, by tracing the ARRL's handling of challenges pertaining to large-scale participation, collaboration, coordination, cooperation, sharing, and distribution, this chapter explores both the continuities and discontinuities between early communities of volunteers and more recent ones like the ones that spawned FOSS and BIOS. On one hand, both older and contemporary systems faced similar challenges and, as the case studies show, the communities that form around these systems have many common characteristics. On the other hand, the cultural and historical context is very different, and there are no direct causal connections between these systems. To overcome this gap, the analysis will focus on actors' categories, primarily the notion of 'community,' which is a key term that reoccurs in both early and contemporary systems, and allows us to discuss the continuities between these systems in meaningful terms.

Second, in my investigation of this story I will focus on the processes by which the ARRL demonstrated the power of an alternative social structure in overcoming perceived technological limitations. I will argue that collaboration and participation become important aspects in the social negotiations around wireless technology, and that overcoming the challenges created by collaboration and participation are used in the actors' attempts to influence government regulation during the process of wireless's stabilization. As outlined in Chapters 2 and 3, Lessig's theory shows how regulation using the law intertwines with regulation by code and technical architectures. This story shows how the categories of 'law' and 'code' are anything but solid, and how users' resistance helps define the boundaries of both, helping us reconcile Lessig's theory within social constructivism. To do so I will introduce the concept of affordances, and discuss how those are socially constructed.

Third, in the preceding chapters I outlined the idea that openness and enclosure are two opposing but complementary notions rather than primal absolutes and that the tension between them had been, and continues to be, a major influence on the social construction of technological systems. Through the ARRL's story I will explore the notion that participation and voluntarism in this technological system were primary mechanisms of democratic culture to the extent that they allowed participants to obtain meaningful roles in their communities. The 'relay mission' was a notion that allowed individuals to come together as a community. As I explained in chapter 2 through Julian Kilker's work, identity theory suggests that individuals express their personal identity through their technological choices. There is a reflection of the same dynamic for groups of individuals working together. I will explore much of the same dynamics in the story of the Ground Observer Corps in the next chapter as well.

Background – Identifying the actors in the early days of radio

To contextualize the ARRL let me start by making an important clarification about what 'radio' was at that time. In the second half of the twentieth century, 'radio' had become increasingly synonymous with 'broadcast radio,' but in its early days radio was understood differently. My analysis of the ARRL will focus on the period between 1899, the year Marconi first introduced 'wireless' to an enchanted American public, demonstrating a technology for point-to-point communication between individual entities, and 1922, the year that the first National Radio Conference convened, and WAEF, a radio station controlled by AT&T, included advertising in its broadcasts, establishing the foundation of a business model focused on broadcasting.[2] Marconi and the empire that he built represent commercial radio operators, which in this period of interest, conceive of radio not as a medium for broadcasting but, rather, a means for point-to-point communications, primarily for use in naval and business operations where the telegraph and telephone couldn't unfold their web of wires. Accordingly, in the first two decades of the twentieth century radio businesses were either: (1) operators who offered wireless communication services; or (2) wireless equipment manufacturers. Several early companies, Marconi's included, belonged to both groups.

Commercial radio operators like Marconi were in the business of transporting messages for service fees. From an analytical perspective one can say that they were part of a commercial-wireless technological frame, which saw radio as a newly discovered resource that could become the basis of very profitable business strategies if only it could be protected using strong intellectual property protections. As their key customers these companies courted the Navy and commercial ship operators. Their hope was to replicate the success that the telegraph and telephone operators enjoyed inland in the untapped market of the ocean. This business strategy relied on the fact that strong patents allowed these proprietors to offer vertically integrated solutions, which included research and development of wireless equipment, equipment leasing to customers, and professional services that were offered by their own trained personnel,

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[2] Susan Douglas finds that these years were foundational to what would become the American broadcasting industry. See Douglas, *Inventing American Broadcasting, 1899-1922*.

which manned naval and coastal radio stations. The Marconi Company was not alone in this business. Other companies like United Wireless Co. (later taken over by Marconi), the Radio Telephone Co.,(which was owned by Lee DeForest, who invented and patented the Audion, the first vacuum tube) and RCA had similar business strategies. Patents were essential to this integrated strategy because they gave an exclusionary right over essential components of the business. For example, control over tuning and amplification techniques gave the Marconi company a huge business advantage by allowing extended range of service. Understanding the importance of these patents, several of the inventors were involved in litigation against one another for patent infringement; in addition, many were involved in serial mergers and acquisitions.[3]

Importantly to this story, commercial service providers were not the only actors exploring radio at the time. Marconi's invention, which was widely covered in the popular press, captured the public imagination and spurred a huge interest in radio by the public and by the government. Different government departments, including the Navy, started experimenting with the new technology as soon as it was introduced. In addition, amateur experimenters, many of whom came from a culture of electrical experimentation, started building home-brewed wireless stations and going on the air. From 1899 to 1912 the number of amateurs was constantly growing, and they were taking up larger and larger portions of the spectrum. In an era in which fine-tuning was not yet mastered and any transmission 'polluted' a wide range of frequencies, this was becoming a problem. According to some estimates, by 1909 amateurs represented

[3] See for example the story of the fights over regeneration, fought between Armstrong and DeForest detailed in Sungook Hong, "A History of the Regeneration Circuit: From Invention to Patent Litigation" (paper presented at the 2004 IEEE Conference on the History of Electronics, Blechly Park, 28-30 June 2004).

between 80-85% of the overall number of transmitters, and in some cases operated better equipment than commercial firms.[4]

For the commercial operators this presented both a problem and an opportunity. The main problem was that the air was cluttered to a degree that made it often hard to get a signal across the ether. Part of the reason for this situation was that the Marconi company held the patents for essential technologies for both reception and transmission and prevented competing firms like United Wireless from using these technologies.[5] Under these conditions and with no radio regulation whatsoever, the notion that everyone had equal rights to the air often meant that commercial operators couldn't function properly.[6] This, of course, was not a tenable solution in the commercial operators' eyes, and, as I will show, they sought regulatory relief. The opportunity that amateurs presented was based on their potential to become customers for equipment and also a source of inspiration for technological improvement.

Where each commercial company stood in respect to amateurs depended on what its business model was.[7] As briefs filed to Congress during in 1910-1912 hearings that discussed wireless regulation show, companies that focused on services sided with the government departments and the Navy in their calls to regulate amateurs; companies that wanted the amateurs as customers sided with them. The Marconi company sided with the amateurs, in part because the amateurs interfered not only with the commercial operators but also with the Navy's radio operations, and the Marconi company, who had superior tuning technology, hoped that such interference

[4] Linwood S. Howeth, *History of Communications-Electronics in the United States Navy* (Washington, D.C.: United States, Government Printing Office, 1963), Ch. XII.
[5] As discussed later, for amateurs patents were often not a big impediment, because they didn't care to respect them.
[6] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 28.
[7] Howeth, *History of Communications-Electronics in the United States Navy*, Ch. XII.

would force the Navy to replace its obsolete equipment with Marconi's equipment and services.[8]

Early radio regulation and the position of the U.S. Government

As early as the turn of the twentieth century, the U.S. Department of Agriculture, among other government departments, realized the value that wireless technology could bring to the government. Government officials understood 'wireless' within their technological frame, as an essential tool for the proper operation of government. However, various government departments started using wireless without coordination amongst themselves, the Navy, the Army signal corps, or the commercial and amateur operators. Finally, in 1904, in order to resolve the conflicts that ensued and to plan the government's role in the development of this new technology, President Theodore Roosevelt appointed a board, consisting of representatives from the various agencies, to prepare recommendations for coordinating government development of radio services. The resulting report proposed assigning most of the oversight of government radio to the Navy Department and recommended significant restrictions on commercial stations.[9]

In 1906, in accordance with the recommendations of the Roosevelt board from two years prior, the U.S. sent a delegation headed by Navy officials to an international meeting that was held in Berlin to pursue an international agreement on global standards for radio regulation. The resulting 1906 Berlin Convention called for strict regulation and direct government involvement in radio operation. The Navy-controlled U.S. delegate readily adopted the convention's resolutions since they perceived them

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[8] Ibid.
[9] Thomas H. White, *United States Early Radio History* [Web] (EarlyRadioHistory.com, 2006 [cited 06/15 2006]); available from http://earlyradiohistory.us/sec023.htm.

as perfectly aligned with the U.S. government's desired policy.[10] From an analytical points of view one can say that the technological frame of international regulators in Berlin was similar to that of the U.S. Navy to the degree that it perceived wireless as an important national resource, and as such believed it should be subject to government regulation and international agreements. The U.S. delegate signed the convention and came back home only to find strong opposition during the discussion in Congress that aimed to ratify the convention and turn it into law. The opposition came from groups with an alternative interpretation of wireless, including commercial operators who saw the airwaves not as a national resource but, rather, as a fertile field for business, and from amateurs who perceived the airwaves and radio technology as a public commons to which every citizen should have equal unfettered access rights. The resulting debates stalled the ratification process for several years. The Marconi Company, which stood to lose the most from the new regulations, was among the most vociferous objectors. Its president at the time, John W. Griggs, who was formerly Attorney General of the United States, called the convention 'unconstitutional' claiming that since radio was a recent discovery an assent to the Berlin Convention would be premature. [11] He also claimed that the convention would commit the government unnecessarily to a policy of government operation of wireless telegraphy for commercial purposes. Other wireless operators agreed. As expressed in editorials of professional magazines at the time, amateurs too opined that any unnecessary regulation of radio should be avoided since it was a new art, still in its infancy, and attempts to regulate it would stifle innovation.[12] In weighing business interests and the amateurs' rights against the government departments' and Navy's position, Congress

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[10] "International Wireless Telegraph Convention (Convention Radiotélégraphique Internationale)," (Berlin, Germany: printed by the Government Printing Office in Washington, D.C. for the Navy Department's Bureau of Equipment [N5.2:W74/6], 1906).
[11] Howeth, *History of Communications-Electronics in the United States Navy*, 151.
[12] Ibid., 152-54.

leaned towards the commercial interest and voted against regulation. The ratification of the Berlin Convention document was stalled, and the discussions went into multiple rounds of debates for four more years.

Overall, in the period from 1902-1910, over twenty bills dealing with radio were introduced to Congress. Until 1910, none of them had passed.[13] In each of these rounds of debates the different social groups kept repeating their entrenched interests: the Navy kept claiming that radio was an essential technology that must be closely regulated; the commercial operators and the amateurs wanted the government to keep its hands off the new technology, each for their own reasons—amateurs relied on ideals of experimentation, commercials wanted Laissez-faire capitalism.[14] Importantly, however, at this point the amateurs' position was not articulated with one voice. Several amateurs represented their individual opinion in these debates, but amateurs were not organized as a group. This situation started changing in 1909, when the first radio clubs self-organized (see below).

As radio became more and more popular, more and more stations were 'polluting' the airwaves and everyday interference only increased. All sides of the debate understood that regulation was needed in the face of several naval accidents. Consequently, the winds in policy circles were changing, and on June 24, 1910, the Navy won a round of legal battles when Congress passed an act that required regulation of radio apparatus and operators on certain larger sea vessels.[15] In its attempt to balance two competing technological frames, the law followed only some of the standards specified by the Berlin convention including the requirement for certification of radio operators, and the demand from large vessels to carry radio

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[13] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 28.
[14] Howeth, *History of Communications-Electronics in the United States Navy*, 153.
[15] Ibid.

equipment. Importantly, this act did not impose licensing requirements for ground stations even though the Berlin agreement called for it.[16] Mandating vessels to carry radio equipment and trained personnel was a boon for commercial radio operators who now had increased business opportunities without the shackles of licensing. It was also good news for amateurs who could continue to operate their land-based stations unaffected.

In the next two years, however, in the international arena, other nations, mainly Germany and England, the superpowers of the time, were preparing for a second international radio conference, planned to assemble in London in 1912 in order to amend the Berlin Convention. Given its inability to ratify the earlier convention, the U.S. risked being excluded from the talks and losing its influence over international radio standards. The government clearly understood the potential adverse military and commercial repercussions of such potential exclusion and wanted to avoid it.[17] This risk led to pressure from the Congress's Foreign Relations Committee, which finally called the Senate into action. Six years after its delegate signed the Berlin convention, the U.S. was finally getting ready to ratify it and thus the invitation to London was re-instated.[18]

As the regulations were being negotiated in Washington D.C., several thousands miles to the North a major naval disaster occurred that would accelerate legislation. On April 15, 1912, the Royal Mail Ship Titanic, the crown jewel of modern naval technology, hit an iceberg and soon thereafter sank to the bottom of the ocean taking with it hundreds of lives, including many rich and famous celebrities. The Titanic was equipped with a wireless transceiver, operated by an employee of the

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[16] White, *United States Early Radio History* ([cited 12/04/08]).
[17] Howeth, *History of Communications-Electronics in the United States Navy*, 161.
[18] Ibid.

Marconi Company, who was able to send distress signals to nearby vessels. Arguably, the several hundred passengers that were saved from the ship's sinking wreck owe their life to wireless transmissions that alerted ships in the Titanic's vicinity and called them to the rescue. Several other nearby ships either did not have a receiver or in one case, turned it off for the night, thus preventing a more fruitful life-saving effort that could have potentially saved the lives of hundreds more.[19] At the same time radio amateurs on the coast followed the developing drama remotely, interfering with the rescue operation and spreading a cacophony of half-truth and rumors concerning the mission's status. One erroneous message later made a headline in the New York Times, stating that all passengers were safe and that the Titanic was being hauled back to shore.[20] The ugly scars of this incident would shape the face of radio regulation for many years to come. Unlike common arguments to the contrary, the Titanic's disaster was *not* the prime cause for radio regulation, which was already underway, but it most probably helped diminish objections to such regulations.[21]

With the Titanic's disaster in the background, the negotiations in Congress were finally settled. The result of six years of debates was a comprehensive "Act to Regulate Radio Communication," signed into law on August 13, 1912.[22] The Radio Act of 1912, as it became known, aimed to: (1) mandate that all ships of a certain size carry wireless equipment and the manpower necessary to operate it; (2) organize the licensing of ground stations in compliance with international standards; (3) allocate the radio spectrum, which was considered scarce, and set divisions among different

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[19] "Carpathia Arrives with Survivors," *Waterloo Evening Courier*, April 17 1912. See also *Frequently Asked Questions About Rms Titanic* [Web] (RMS Titanic Inc., 2006 [cited 06/21 2006]); available from http://www.titanic-online.com/index.php4?page=faq.
[20] Douglas, *Listening In : Radio and the American Imagination, from Amos 'N' Andy and Edward R. Murrow to Wolfman Jack and Howard Stern*, 60.
[21] H.G.J. Aitken, "Allocating the Spectrum: The Origins of Radio Regulation," *Technology and Culture* 35, no. 4 (1994): 691.
[22] *The Radio Act of 1912*, 264, 62nd Congress, (August 13, 1912).

uses, separating military from commercial uses and ensuring that commercial interests will not create de-facto monopolies; and (4) solve the problem of interference by non-licensed amateurs.

To help achieve these objectives, the law delegated the regulatory responsibilities to the Department of Commerce's Bureau of Navigation, which managed wireless regulation until 1927 when the Federal Radio Commission was created. By delegating regulatory power to the Department of Commerce, Congress broke away from the Navy's view of wireless primarily as a military technology. The amateurs' interests were still severely compromised. "Private stations" were limited to a wavelength of 200 meters and a maximum power of 1kw. Since the known usable spectrum at that time ran from about 300 to 3000 meters (1000 khz to 100 khz),[23] the 1912 law seemed like the amateur's closing act.

Before looking at how the amateurs' reactions softened the blow, let us note that the government's understanding of radio technology as expressed in the Radio Act of 1912 manifests a tension between enclosure and openness that recurs in similar systems. On one hand, the spectrum was perceived as a public good to which every citizen can and should have equal access, but on the other hand, it was perceived as a scarce resource with significant military and commercial value that should be carefully controlled lest it be overexploited. In his account of early radio regulation, which discuss in more details below, Hugh Aitkeen discusses this situation in the following terms:

> Our starting point is the conception of the broadcast spectrum as a common-property resource and therefore as a resource inherently subject to the dangers of overexploitation, overinvestment, and falling yields that have been thoroughly documented with reference to (for example) fisheries, oil reserves, and groundwater basins. Such

[23] Bill Continelli, *History of Amateur Radio* [Web] (2005 1996 [cited 06/21 2006]); available from http://www.ham-shack.com/history01.html.

> resources have always presented problems of public policy, essentially because users of the resource do not take account of the full social costs of their actions, and consumers do not pay the full price of what they consume.[24]

The decision to, on one hand, allow amateurs to continue their hobby and not expel them from the spectrum commons altogether but on the other hand, to allot to them wavelengths that were believed to be commercially worthless, is an early attempt to find balance along this axis. This tension was articulated by Congressman Roberts who for several years was trying to promote various regulations and was influential in the discussions leading to the Radio Act of 1912. Chairing a hearing before a subcommittee of the House Committee on Naval Affairs in February 1910, he said:

> [My purpose is] to bring about some reasonable regulation of the air in the interest of not only the government service in wireless, but of the commercial and the amateur as well. I judge, from communications I have received and from articles I have read in papers, that there is an impression in the minds of the amateurs of the country that the purpose of the bill is to put them out of business entirely. I wish to disabuse their minds of that idea; it is not to prevent any person having a right to use the air for wireless communication from so using it, but simply, through a board, to make appropriate regulations to control that use of the air so that one will not be needlessly and unnecessarily interfering with the other, that all will have their rights…[25]

In addition, this case raises one of the most fundamental policy questions that are pertinent to the role of government in regulating technological systems that make use of the common-property, whether closed or open. Should the government intervene in technology's operation, through regulation or otherwise, or should it trust the market's invisible hand? This debate and the tension in the perception of such resources would underwrite radio's regulations for years to come, and would re-

[24] Aitken, "Allocating the Spectrum: The Origins of Radio Regulation," 690.
[25] Committee on Naval Affairs of the House of Representatives, *Hearings before a Subcommittee of the Committee on Naval Affairs of the House of Representatives on H. J. Res. 95*, 1910.

surface in several of the other systems I will investigate, particularly in BIOS. The answer to such policy questions largely depends on the perception of the commons and an understanding of potential ways to protect it. Is radio spectrum a scarce resource? If so, what sort of scarcity does it manifest?

In his comprehensive *Technology and Culture* review of the history of radio regulation, Hugh Aitken makes an important distinction between two types of scarcities that he defines as follows: (1) a physical/technological scarcity is a condition under which a resource can be exploited only to a limited extent; and (2) a political/social/ economic scarcity is a condition under which no markets exist to facilitate transactions in the scarce resource.[26] The distinction is important since the solutions to the two types of scarcities are different. For efficiently allocating scarce resources of the first type regulation is needed while for allocating the second type conditions for the existence of efficient markets can be created.[27]

Influenced by the interpretation offered by the Navy and by commercial interests, Congress clearly perceived the spectrum scarcity as a scarcity of the first type, and therefore opted both in 1912 and then later in 1927 for regulatory solutions that disfavored the amateurs who were initially voiceless in these discussions. I want to suggest that the forming of the ARRL was in many respects a direct response to these regulations and the problems that they prescribed to radio amateurs.

The Navy's use of regulation for enclosure

I read the attempts of regulation from 1902-1912 as attempts to close off a technology that in the regulators eyes was too 'open' and under-regulated; cast in

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[26] See Aitken, "Allocating the Spectrum: The Origins of Radio Regulation." and *The Radio Act of 1927*, 632, 69th Congress, (February 23, 1927).
[27] As Aitkeen notes, market are believed by many economists to be much more efficient than governmental regulation in resource allocation.

those terms, it becomes obvious that the key driver for enclosure was the U.S. Navy. As I noted earlier, the navy played a determining role in this story by helping the government set its policies and by influencing regulation. In the course of sixteen years, from 1899, the year Marconi first demonstrated the broad capabilities of wireless, to 1915, when the secretary of the navy called wireless an "indispensable adjunct to naval communication"[28] the Navy switched its position from opposing the new technology to endorsing it, and in the process became a rival for the radio amateurs and the networks they were building. In the Navy, Marconi and the other wireless inventors hoped to find an avid customer, but there were several impediments to rapid adoption of wireless technology in the Navy, and debates about the meaning of wireless and its military value. First, one must remember that the Navy was a distributed organization with internal politics, which made the acceptance of wireless problematic to the extent that it fell under the aegis of multiple Navy departments that couldn't agree on how radio could and should be used.[29] Then there was a larger political problem concerning national security. The navy lacked wireless capabilities of its own but it feared that relenting control to private interests, and particularly to the British Marconi Company, would put the U.S. in a military disadvantage. The exclusionary business practices that Marconi selected when attempting to create a vertically-integrated wireless communication network turned out to be a political time bomb because they raised fears that lack of control over wireless would be a loophole in American national defense. According to their internal discussion, it's clear that Navy officers believed that the historical expansion of the British Empire was enabled to a large degree by reliance on the telegraph and underwater communication

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[28] Douglas, *Inventing American Broadcasting, 1899-1922*, 106.
[29] Howeth, *History of Communications-Electronics in the United States Navy*, Ch. 4.

technologies. This interpretation only exacerbated the Navy's fears that foreign domination over wireless would put the U.S. in an unfavorable military position.[30]

As an early solution, the Navy wanted to buy equipment from Marconi and operate it on its own but the new technologies were expensive and the Navy was short on cash. To overcome this, in 1899 Marconi offered a long-term leasing option but the Navy thought the price was exorbitant and the lease terms too harsh. Feeling secure with the superiority of his technology protected by strong patents, Marconi decided to be a tough negotiator. This resulted in the Navy being alienated and not buying equipment from Marconi, until 1906, when Marconi changed its policies and allowed direct sales once more.[31]

In the meantime internal objections to the Navy's use of radio waned; within a few short years, looking at what the commercial operators were doing with it, the Navy came to realize that wireless was not only feasible but an essential tool for modern naval operations. With the realization that radio was an essential modern means for military operations, the Navy moved swiftly to try and control this technology. Failing to take control over radio using market forces, the Navy now tried to regulate wireless using the law. However, by then the Navy faced a new problem: interference from the shore. In a letter of from March 7, 1904, addressed to the Secretary of the Navy, Rear Admiral George A. Converse, the Chief of the Bureau of Equipment who was in charge of radio technology, recommended that the Navy Department consider requesting the President to issue an executive order placing all radio stations belonging to the Government on or near the coast under naval control. He wrote:

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[30] The American Marconi Company was dominated by the British parent company, and this created fears in the Navy from being dependent upon it. See Ibid., 36.
[31] Ibid., 145.

> Owing to the fact that the principal use to which wireless telegraph is likely to be put for many years is connected with the sea and account of the confusion that may arise from numerous independent stations being established in the same locality, the Bureau is of the opinion that it would be advisable to put all government wireless-telegraph stations on or very near our seacoast under the Navy Department and perhaps to have the Government take control of the entire wireless-telegraph service along the coast…[32]

As I noted earlier, the Roosevelt board of 1904 took a similar view and suggested that the Navy gain authority over wireless, a decision that resulted in Navy officials helping to dictate government policy. But the delay in ratifying the Berlin Convention and the transfer of authority over radio regulation in 1910 to the Department of Commerce was alarming to the Navy because as the Navy saw it, the problems were intolerable.

Already several years before the Navy had started issuing "certificates of skill in radio communication," but neither amateurs nor the commercial operators (until the Ship Act of 1910) had any good reasons to actually apply for such certificates. By 1910 the Navy had issued only 477 of these certificates, the majority to amateurs, but this was a fraction of the overall number of stations in the country.[33]

In November 1911, Lt. Comdr. David W. Todd, the Navy's Head of the Radio Division and an influential actor in legislative circles, spoke before the American Society of Naval Engineers and described cause for the Navy's alarm. He noted that:

> There is no law, nor order and with an increase of the number of commercial shore stations conditions will be chaotic. Any wireless company, any individual, can put up a station anywhere, of whatever power or range it or he may please. Any wavelength may be used, any kind of transmitter. There is no restriction as to hours of working. The time signals sent out by naval stations, the information concerning wrecks, derelicts, ice, aids to navigation displaced, storm warnings, all are subject to interruption, by neighboring stations, and the mariner

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[32] Quoted in Ibid., 70.
[33] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 25.

> may listen for them in vain. Vessels in distress may not be able to make known the fact or extent of their plight or their positions, on account of press dispatches being relayed along the coast, or a long invoice of goods being repeated by wireless, for advertising purposes, between cities separated by a twenty-five-cent telegraph rate.[34]

Accordingly Todd suggested that it would be better if the Navy controlled all shore stations for commercial radio communications with ships and that the law should require that all relaying of messages between points adequately connected by landline should be reduced to a minimum. In sum, in the Navy's interpretation up to 1912, both commercial and amateur radio operators represented a key problem, since they competed for spectrum. Many of the attempts at regulation were aimed at solving this (perceived) resource allocation problem. The 1912 act, however, was not what the Navy had hoped for, since it did not endorse the Navy's view of what wireless was. In the years that followed, the Navy kept trying to amend the regulation but only when the U.S. joined World War I did it gain full control over radio. During 1912-1917 the meaning of radio was changed again.

Resistance to closure – the formation of the ARRL

A dictionary defines an amateur (from the Latin, amator, lover) as "a person who engages in an art, science, study, or athletic activity as a pastime rather than as a profession."[35] In popular culture amateurs are commonly considered as those who rank below professionals, however, when large groups of amateurs come together these distinctions blur. An editorial in the July 1914 issue of the popular science magazine *Popular Mechanics,* informed its readers who through the work of radio amateurs it was now possible "for the private citizen to communicate across great

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[34] Howeth, *History of Communications-Electronics in the United States Navy*, 161.
[35] Amateur. Dictionary.com. Dictionary.com Unabridged (v 1.1). Random House, Inc. http://dictionary.reference.com/browse/amateur [Web] (accessed: October 08, 2007).

distances without the aid of either the government or a corporation." Remarking on the amateurs' achievements, the editor noted their claim that "the organization of the relay league actually marks the beginning of a new epoch in the interchanges of information and the transmission of messages."[36] This editorial comes just two years after the certification requirements mandated by Radio Act of 1912 gave an ostensible kiss of death to amateur radio and reduced the number of stations from around 10,000 before the act to 1,200 after it.[37] In addition, the limitation of amateurs to wavelengths of 200 meters and down and to 1KW of transmitting power meant that most stations were limited to a maximum range of 25-30 miles or sometimes much less than that, until they later found a way to communicate via short-wave. One may ask, then, what happened in those two years that enabled amateur networks to thrive and compete with the professional military and commercial networks? The answer revolves around two independent but interrelated processes: (1) the surprising discovery of regenerative amplification techniques that allowed long distance communication over the previously-worthless portion of the spectrum allotted to amateurs; and (2) the social organization of the ARRL that allowed for further 'human amplification' by streamlining the collaboration of hams that were geographically distributed all over the country.

Let us look at the technological innovation process first. The reason for hams' limited range was that without amplification the energy heard in the headset of the

[36] Quoted in DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 40. DeSoto's book from 1936 is the only published book on the history of the ARRL. Given DeSoto's privileged access to source material and to the ARRL's senior staff in his capacity as an ARRL employee in the years preceding publication, the main value of this work lies in the level of details that it provides. However, it is extremely technologically determinist (on page 10, for example, DeSoto writes: "the amateur radio of today [1936] is the consequence of the entire development of civilization—an inevitable, inescapable product of natural law.") Accordingly, I rely on DeSoto primarily as a reference guide to the sequence of key events and to primary and secondary sources, while looking critically at his findings and conclusions.
[37] Ibid.

receiving party had to come, through the air, from the transmitter. At amateur wavelength and power limitations this energy was miniscule and significantly limited a station's operational range. Limiting the power and the number of operating stations meant that communication among amateurs was significantly hampered. Then in 1913, Edwin H. Armstrong, a 22 year-old undergraduate student at Columbia University's engineering school and an avid amateur who was disappointed with the poor results of his radio set, explored the principles of regeneration.[38] Having learned how Lee DeForest's Audion radio tube worked,[39] Armstrong re-designed it after he noticed that by feeding back part of the signal in the tube's output back into its input, he could create a loop or, in essence, an amplifier. This regenerative circuit, as he called it, was able to amplify received signals a hundred fold. Two Audions serially connected under Armstrong's scheme could elevate the signal strength by a factor of 2000. The regenerative circuit soon became the subject of a bitter patent war. After improving it, Armstrong patented his invention and sold his rights to RCA. At about the same time, Lee De Forest sold rights to a similar patent to AT&T. Starting in 1922 Armstrong found himself in a twelve year patent war, between himself, RCA, and Westinghouse on one side, and De Forest and AT&T on the other. Armstrong won the first round, lost the second, and eventually lost his rights in a contested ruling of the United States Supreme Court which granted De Forest and AT&T the regeneration patent rights.[40] It is noteworthy that Armstrong was a student at the time of his invention. Just as in the case of Linus Torvalds that I discussed in Chapter 3, this story shows how a technological innovation that is developed outside the industrial/business research frame, soon become the subject of business claims and the potential source of

[38] *Fifty Years of A.R.R.L.: A Reprint of Historical Articles from the 1964 Issues of Qst*, (American Radio Relay League, 1981), 20-21.
[39] The Audion is an ancestor of the vacuum tube, and is generally known as a triode a component in which the flow of current from the filament to the plate was controlled by a third element.
[40] Hong, "A History of the Regeneration Circuit: From Invention to Patent Litigation".

fortunes. Another important aspect of this invention, also similar to Torvalds's, was that it was easy to replicate. Once proven, anyone possessing an Audion and a few other simple electrical components could use Armstrong's blueprint to change the circuitry of their radio set and create a regenerative circuit. Word about this development spread quickly over the ether and amateurs were quick to experiment with it.

A culture of experimentation was not foreign to hams, many of who came from the ranks of early experimenters with electrical technologies and had a lot of experience with electromagnets, motors, and batteries. Hams who experimented with regeneration found it hard to believe, but they could actually communicate to distances of hundreds of miles without increasing their power or changing their frequency.[41] Sadly for many amateurs, however, Audions, the key components in the design, were scarce and expensive, since they were patented by DeForest and manufactured only by his company who couldn't keep up with the surging demand. A quest for an Audion, so the key actors remember, was one of the factors that led to the second development, the creation of the relay league in 1914, but to understand this I have to go a few years back.

The typical amateur station circa 1910 consisted of an induction coil, a condenser and spark gap for the transmitter, and a simple coherer-decoherer or galena crystal for the receiver/detector, usually connected to a single telephone headset. Some better-equipped amateur stations had receiving tuners in the form of loose-couplers. These stations often outperformed commercial stations that could not use this important technology because Marconi held the patents for it, a legal barrier that the amateurs didn't really care about. DeForest's Audion wasn't widely used because,

[41] *Fifty Years of A.R.R.L.: A Reprint of Historical Articles from the 1964 Issues of Qst*, 20.

being patented, it was scarce and expensive.[42] As a result most stations were not tuned, the airwaves were cluttered, and interference among amateurs, the Navy and commercial operators who competed for airwaves was commonplace.

During 1909-1911, while fighting the regulatory measures that were being debated in congress, in several places around the country radio clubs formed that tried to find self-imposed regulatory solutions to the interference problem. In Lessig's terms, this was an attempt at self-regulation by norms where the market, law and code failed. After 1912, when the new law kicked in, the interference problem improved to some degree, but not entirely. Separated by frequency from the Navy and the commercial operators, amateurs still faced the problem that many of their own stations competed with each other. Many amateurs understood that self-regulation might offer some solace, and several more radio clubs organized, mainly on the East coast. David L. Moore, the founder of the Hartford, Connecticut, Radio Club recalls the logic for his club's formation:

> …the club was formed on January 14, 1914…in hopes of bringing some order out of the unregulated ether. The conflict then was mainly between the hams with tuned signals…and those whose transmitters consisted of Ford coils whose spark simply went to antenna and ground. This was really an 'all-wave' sending device which rivaled the later jamming devices of the Russians…[43]

Important to this story, two of the members of the Hartford Radio Club were Clarence Tuska and Hiram Percy Maxim. Tuska was a 15 year-old whiz kid who built rubber band powered model airplanes for pocket money. Maxim was a 44 year-old

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[42] See Ibid., 8. The very idea behind a patent is to create a limited monopoly that prevents competition. A common outcome is that the patent holder controls the price by either controlling the supply or by charging other manufacturers licensing fees that increase the price.
[43] Quoted in Ibid., 9.

inventor who became famous by inventing several automobile improvements and the Maxim machine gun.[44]

Tuska recalls that when the model airplane fad had waned, he tried to make some money from his new hobby, amateur radio. He built an amateur station, boxed it, and tried to sell it in a local toy store in Hartford. Maxim bought it for his kid, but returned it after he decided it was not good enough for his needs. Insulted, Tuska went to Maxim's house to inquire about the problem with his design. Maxim, who was a man of means and high engineering standards that came from a tradition of industrial inventors, insisted that he needed something more professional. Impressed with Tuska's attempt to inquire about the faults of his design, Maxim hired Tuska to build an improved station for him.[45] The resulting station worked well, Maxim and Tuska began a long friendship, allowing Maxim to continue to participate in the new hobby.

Maxim and Tuska then both joined the Hartford Radio club and would communicate over the air when they didn't meet in person. Having operated his station for a while, Maxim soon adopted the amateur measure of success -- the number and distance of stations that a ham could 'work'. Accordingly he wanted to experiment and improve his station by adding equipment to it, and he was determined to buy a rare Audion. Maxim had the money to buy it but Audions were hard to find, and his attempts to buy one from the DeForest company in New York City failed. Through the grapevine he had heard of a fellow ham in Springfield, 30 miles from Hartford, who had an Audion for sale. He tried to communicate with him over the air but despite the short distance he could not 'work' the other guy. Due to some local transmission conditions Springfield was beyond reach. Maxim didn't give up. He

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[44] For Maxim's full biography, see Alice Clink Schumacher, *Hiram Percy Maxim* (Hartford, CT: Electric Radio Press, 1998).
[45] Clarence Tuska, "A Memorable Meeting," in *Fifty Years of A.R.R.L.: A Reprint of Historical Articles from the 1964 Issues of Qst* (American Radio Relay League, 1981).

remembered that in one of the radio club meetings he had met a guy from Windsor Locks, an intermediate location between Hartford and Springfield. He 'worked' the Windsor Locks amateur and asked him to relay his message. The deal was done.[46] Reflecting on the experience Maxim realized that relay could be significant for amateur radio.

The principle of relay in and of itself was not new: ships at sea were using it to communicate with the shore, and early amateur organizations like the Central Radio Association, which was organized in 1911 and claimed to have members from Ohio to the Rockies, were relaying messages for hundreds of miles already. But Maxim realized that relays were a form of social glue. A relay network, Maxim concluded, was an ideal basis for the national organization of amateurs who up to that point were a haphazard group, organized primarily on a local basis with little motivation for cooperation and collaboration. Maxim envisioned an organization that would facilitate relays that would make the 'whole' greater than the sum of its parts by bonding together the amateurs of the country into one self-reliant body that could represent their interests.[47]

Maxim rapidly acted on his plan. In March of 1914, he proposed the formation of the American Radio Relay League to his young friend Tuska, and together they convinced David Moore (Hartford Radio Club's 22 year-old president) to appropriate $50 from the club's budget to mail out invitation forms to all known stations around the country. Maxim also sent letters to *Modern Electric, a* widely read popular science magazines, and *The Electrical World,* a trade journal, announcing a call for participation. These recruiting efforts soon bore fruit. Application forms were flowing

[46] "The Birth of the Arrl," in *Fifty Years of A.R.R.L.: A Reprint of Historical Articles from the 1964 Issues of Qst* (American Radio Relay League, 1981), 10.
[47] *Fifty Years of A.R.R.L.: A Reprint of Historical Articles from the 1964 Issues of Qst*, 11.

in by mail from all over the country. By August 1914 more than 200 relay stations had been set up. In September the ARRL published a map showing 237 stations in thirty-two states and Canada. In October the first call book was published, listing the names, addresses, calls, power, range, receiving speed and operating hours of 400 stations. A 64 year old man owned one station; boys owned other stations. The range of the stations varied from 10 to 350 miles.[48]

In January 1915, conflict ensued between the ARRL and the Hartford Radio Club over the expenses the club incurred in organizing the league. Maxim paid the debt to the club from his own pocket; he and Tuska resigned from the club and soon registered the ARRL as a not-for-profit corporation under the laws of Connecticut with the expressed purposes of "the promotion of amateur radio telegraphy, the organization of amateur radio telegraph stations, the promotion and regulation of amateur radio inter-communication, the relaying of messages from station to station, and the printing and publishing of documents, books and pamphlets necessary or incidental to any of the above purposes."[49] As is clear from this mission statement, relays were only a small part of the league's mission. However in Maxim's view relays were the glue that held it all together, and gave meaning to the organization's existence.

The number of stations grew, and it became clear that some form of publication was necessary to coordinate the actions of the league's members. In December of 1915 the first issue of a new magazine called *QST* came out.[50] The name is derived from the shorthand code of the same letters (aka a Q signal), which meant "calling all Radio Amateurs." *QST* magazine was a private venture by Maxim and

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[48] "The Birth of the Arrl," 10-11.
[49] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 42. and *Fifty Years of A.R.R.L.: A Reprint of Historical Articles from the 1964 Issues of Qst*, 14.
[50] "December Radio Bulletin," *QST*, December 1915.

Tuska, sold for a yearly subscription of $1, but it soon became the league's voice. Its objective was "to maintain the organization of the ARRL and to keep the amateur wireless operators of the country in constant touch with each other."[51] In the years that followed, *QST* developed into a serious publication that included editorials, technical articles, feature articles on members' achievements and records, readers' letters, advertisements for events and equipment, readers' equipment exchange and sales ads, and updated lists of stations. Like in the case of FOSS, in this case too, the core system served as the foundation for a varied peripherals economy that included publications, education, and professional services. Just as in the case of software, there were many businesses built around the technology allowing community members to make a living from their hobby while blurring the lines between amateurs and professionals.

QST was an immediate success. The ARRL saw a 50% increase in membership, which grew to almost 1,000 members by January 1916. *QST's* published list of over 600 known relay stations helped differentiate the ARRL from 'competing' leagues that started forming. Particularly, the ARRL was wary of the *Radio League of America*, which was started by Hugo Gernsback the editor of the *Electrical Experimenter* magazine, in December 1915, and listed Nikola Tesla, the pioneer electrical inventor, and Lee DeForest as honorary members.[52] In an editorial article in January 1916, *QST* warned members against the danger of the multitude of wireless associations that were mushrooming without offering clear benefits to the members. The accusation was that these organizations were simply schemes to sell more publications, demonstrated by the fact that membership in the suspect organizations was always free of charge and had no clear benefits. In contrast, the ARRL showed

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[51] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 43.
[52] Ibid., 46.

that it had actual working stations, and that it made attempts to streamline their operation and cooperation.[53] It seems as if the Radio League of America saw things differently; their certificate of incorporation states that:

> the League is a purely scientific organization. There are no dues, no membership fees to be paid. It has been organized under the auspices of the world's greatest wireless men, who thoroughly indorse its principles. It is not a money making organization, nor is it conducted by a commercial wireless company for its benefit. The Electrical Experimenter has been selected as the league's official organ, as this journal, with the largest circulation of any wireless publication at present, reaches either directly or indirectly almost every wireless amateur in the country to-day. It will publish the league's news from month to month, thereby keeping up the interest of its members.[54]

It seems as if the RLA and ARRL where competing for attention. Initially, the RLA was focused on disseminating information to its members, while the ARRL was focused on bringing them together as a working group. By the fall of 1915, the RLA changed its story, claiming that it was incorporated in order to enroll the amateurs for defense work.[55]

Building the community of hams and the technological frame of relay stationers

Further look at *QST's* early issues suggests that developing a work ethic and a culture of cooperation among hams was one of ARRL's key missions. The editorial in *QST's* first issue read:

> Our greatest difficulty in getting messages through is because the other fellow is not "on." Most of the stalling of messages is due to this one thing. What we must do is to have regularly established definite times at which we will be on duty…another vitally important factor in securing reliable transmission is the LIST OF STATIONS book. This book must be at hand ready for instant reference at any moment. Over

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[53] "Editorial," *QST*, January 1916.
[54] "Certificate of Incorporation of the Radio League of America Inc.," (New York, NY: 1915).
[55] "Wireless Owners Band for Defense," *The New York Times*, November 21 1915.

> six hundred stations are listed in this book, and it is the one which the Government would use in attempting to work through an amateur station in case help were needed.[56]

Maxim realized that the relay work gave the members a sense of mission, and that building the relay network on a national scale was within reach. Encouraged by the surge in registration, he proceeded to outline his grand ambition for a national relay network. In the February 1916 issue of *QST* he outlined a plan for covering the entire country. The plan called for six Main Trunk Lines, three that would carry messages North/South and three that would route East/West (Figure 4-1). The rest of 1916 was dedicated to actualizing the plan. Trunk Line Managers were appointed, and a series of drills was carried in a rigorous manner, with test messages sent every Monday night aiming to explore how far the network had extended. By the end of the year 150 cities could be reached.[57] As a public relations exercise to test the system nationwide, on Washington's Birthday, 1916, a test message was sent to the governors of every state, and President Wilson in Washington. The experiment was a big success with the message delivered to 34 States and the President within 60 minutes. By February 1917, the system was so refined that a message sent from the East coast to the West coast and back took only one hour and twenty minutes.[58]

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[56] "December Radio Bulletin."
[57] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 48.
[58] Ibid., 49. See also "Amateur Wireless Crosses Continent; American Relay League Sending Messages from New York to Los Angeles. Ready for War Service.," *The New York Times*, March 8 1917.

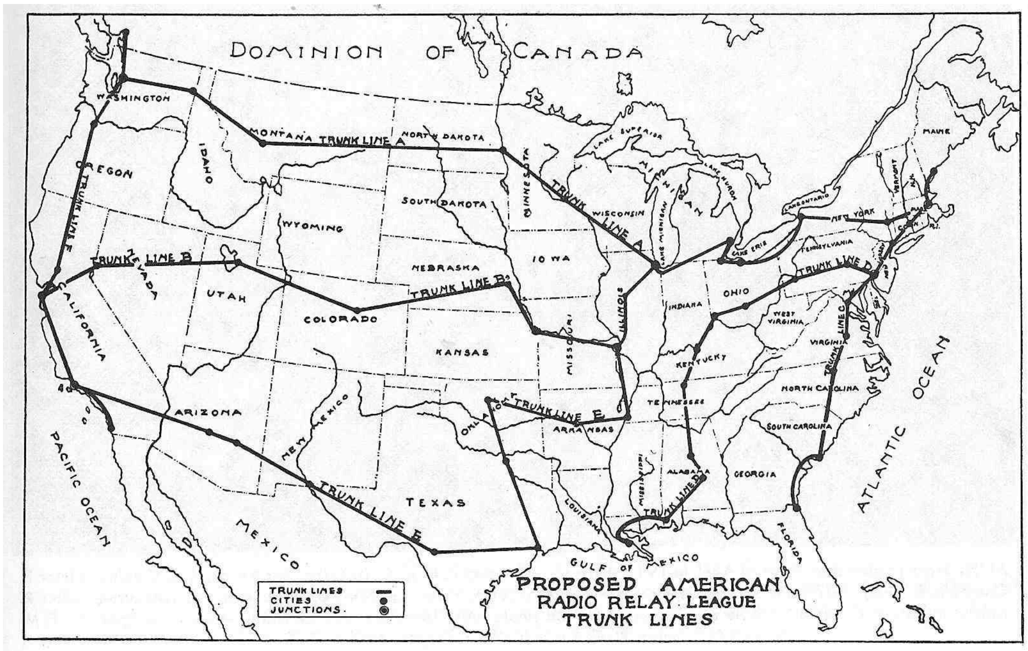

Figure 4-1: Proposed ARRL Trunk Lines (February 1916)[59]

What messages would be transported? It was an odd mix of hundreds of personal messages from non-amateurs to their friends and families across the country, baseball scores and other news sports, test messages, and chatter (known in the amateur jargon as 'rag-chewing').[60] For most Americans at that time, the telegram and telephone were still expensive, and long-distance communication prohibitively so (if it was accessible at all). To those people an alternative network that would offer free communication, was completely decentralized, was not government controlled, and did not require contracts with commercial interests was a welcome alternative. For this

[59] Image source: "Proposed American Radio Relay League Trunk Lines," *QST*, February 1916. During the following year the plan was actualized as designed. On February 6, 1917 a final test was performed, with messages sent from the East coast to the West coast and back, in one hour and twenty minutes. See "Arrl - the Early Years," in *Fifty Years of A.R.R.L.: A Reprint of Historical Articles from the 1964 Issues of Qst* (American Radio Relay League, 1981), 18.
[60] William Perry interview.

reason, the ARRL would later boast that it was “the public parks of the airwaves.”[61] This comparison between the airwaves and the physical commons rests on the same views expressed in the editorial in *Popular Mechanics* that was quoted above, which professes a new era in wireless communication, one in which the government and commercial operators were not necessary. Similar attitudes prevail in the systems that I investigate in the other chapters.

The ARRL’s early years exhibited tensions between, on one hand, its highly organized structure and the rigor and seriousness with which the relay stations were expected to work and, on the other hand, the messy content that was relayed and the participants mixed motivations. Susan Douglas finds that with the creation of the ARRL, for the first time in American history, men were bound together not by necessity but by fun.[62] The role that ‘fun’ plays in bringing hams together stands in contrast to what the directors of the league were trying to portray. As various statements made by Maxim and the other directors in *QST* articles and during congressional hearings show,[63] having fun was not the league’s mission. In an article in *QST* the editor ponders the meaning of what he calls the “ARRL spirit,” and tries to understand what brings about brotherly feelings. He surmises that fun is an effect, rather than a cause. He writes:

> The fact that we are all troubled with the same things, arouses a feeling of brotherhood. The fact that we appreciate one another's failures and success brings us close together. The romance of sitting alone in a little out of the way room among a lot of instruments, and yet be in communication with congenial spirits in other distant and out of the

[61] Perry Williams, interview.
[62] Douglas finds that those involved in the new hobby saw “larger-than-life images of themselves in popular books, magazines and newspapers.” See Douglas, *Inventing American Broadcasting, 1899-1922*, 206. Offering an alternative view, in a study of hams’ technical identity, (albeit for a later period, after WWII) Haring finds that gender identities and quests of masculinity played a big role in sustaining the hobby, see Kristen Haring, "The "Freer Men" of Ham Radio: How a Technical Hobby Provided Social and Spatial Distance," *technology and Culture* 44, no. 4 (203).
[63] See detailed discussion below.

> way little rooms, is conducive to profound and reverent thoughts. The fun which bubbles over from so many of us and finds expression in QST, is one of the interesting manifestations of the effect of our work upon us.[64]

Clearly according to this view, fun is perceived as an 'effect' of the ARRL's work and not its cause or motivation; however, this understanding existed side by side with the notion that saw in the ARRL's work mainly a social activity. In addition to the conversations over the airwaves and through the pages of *QST*, hams had a chance to interact with one another in self-organized festivals, which became known as 'hamfests'. These events, often started as nothing more than local picnics for the members of a local radio club, soon became a venue for equipment manufacturers to vend their wares, for informal gatherings where knowledge was transferred among amateurs, and not much later, for organized technical programs sponsored by the league. Hamfests quickly grew from local to regional to statewide gatherings, and by September 1921, the ARRL organized its first national convention in Chicago.[65] As outlined in Chapter 3, a similar need for meeting online and offline occurred in the early days of FOSS. In the case of radio, hams communicated over the air using their own radio sets, while hackers communicated using newsgroups and forum postings. In both cases the periodic physical meetings soon became essential elements in the building of a community, which in between meetings had to imagine itself as a whole. In Kelty's terms, as discussed in Chapter 2, these are the moments in which a social group becomes a 'recursive public', aware of its own means of maintenance. In sum, this case shows how interpretive flexibility exists even within a social group. For Maxim the ARRL was a relay organization, for many of the members it was a social network centered on a technical hobby.

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[64] "The Arrl Spirit," *QST* 17, no. 5 (1917).
[65] William Perry interview.

While buttressing the community was clearly important, Maxim realized that in order to maintain the sense of mission, it was equally important to portray the relaying work as life-saving. Importantly, one should remember that the inception of the ARRL occurred while the First World War was already looming in Europe. In a letter to the Secretary of War, which was proudly reprinted in the inaugural December 1915 issue of *QST*, Maxim writes:

> The league is a purely amateur organization. The exchange and delivery of messages is purely complementary … [however] many of our stations have already been of service in establishing communications when flood has prostrated the telegraph and telephone lines. We believe we can be of service to the country under many conditions similar. Our membership is rapidly growing…many of our stations are owned by men of wealth some by young men, some decidedly boys…if we can be of any service to our country we shall be glad to serve in any capacity requested.[66]

In Maxim's view the ARRL's was at one and the same time a participatory, inclusive, volunteer organization that also had huge potential for institutionalized relay missions. As the other case studies demonstrate, and as I will discuss in further in Chapter 7, this understanding represents a consistent duality observable in communities of volunteers, which are at once both open to participation and guided by strict norms and hierarchical social structures. The fact that, in theory, anyone, young or old, urban or rural, rich or poor, man or woman, could become a ham, did not contradict the fact that by becoming a member of the community one had to adhere to its standards and appreciate its sense of mission. As I suggested in the introduction, 'open systems' are open to volunteer participation, but they still abide by strict social stratification. Clearly, a stable social structure is essential both for internal governance and for interfacing with external actors; without it, open systems could not maintain

[66] Hiram Percy Maxim, "Letter to the Secretary of the Navy," *QST*, December 1915.

the conditions that ensure their continued openness. In Kelty's terms, a recursive public is primarily concerned with its own means of maintenance; clearly this includes the maintenance of social structure.[67] Maxim's repeated return to the relay mission as the main organizing principle of the league shows that he perceived amateur radio not as an individual activity but, rather, as the technology that allowed a community of hams to work towards a shared goal. When, in 1917, Congress was hearing stakeholders as it planned further radio regulation, Maxim sent a long letter to the Merchant Marine and Fisheries committee where the discussions were being held, announcing that he was actually in favor of some form of regulation. He writes:

> The American Radio Relay League, of which I am president, is an organization of approximately 5,000 amateur radio station owners scattered in all the States of the Union. Our object is the perfection of radio relay routes by means of which messages may be sent between private citizens in any part of the country free from all charge. We have been in operation since May 1914, and at present are handling between 100 and 500 relay messages every night…our members include not only young men, but also men of affairs… I have considered carefully the proposed radio bill and I desire to go on record as approving those parts of it, which concern amateurs because I believe its enactment into law will reduce radio interference, which is now the greatest difficulty, which confronts us. I recognize that the proposed bill will confer greater powers upon the Navy Department, Department of Commerce and the President in dealing with us amateurs; but I believe these greater powers will help our work rather than retard it. These authorities can not but appreciate that it is from the ranks of us so-called amateurs that the talent necessary to carry on both government and commercial radio work is principally drawn; that we amateurs and the many manufacturers who we support have already been the source of several valuable improvements in radio science, and that in the time of public need our well organized relay trunk lines and our very efficient stations in the various States of the Union might easily be of incalculable value to our country…[68]

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[67] Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*, 2.

[68] The Merchant Marine and Fisheries, *Hiram Percy Maxim, Arrl President, Statement to the Merchant Marine and Fisheries Committee on H.R. 19350: A Bill to Regulate Radio Communications*, 01/11/1917 1917.

While clearly drafted with rhetorical objectives, there are several noteworthy parts of this statement that would help us understand Maxim's technological frame vis-à-vis the other relevant social groups. First, note the positioning of the ARRL not as a league of amateurs but of semi-professionals. As such the statement stresses that the ARRL is essential in several respects that include: (1) support for commercial equipment suppliers that rely on the ARRL for their livelihood and for product improvements; (2) as a feeder for human labor into commercial and government radio operations; and (3) as a backup for commercial and government radio communication in times of emergency. It also stresses the fact that the ARRL is not an organization of young men only but that participation extends to other social groups as well.[69] This positioning is strategic and is aimed in changing the common perception of the ARRL as an organization of young hoodlums that was common in the eyes of some government officials. Herbert Hoover, Secretary of Commerce and radio's chief regulator in the 1920s (and later, president of the United States), for example, is quoted as recalling a conversation with key ARRL personnel, perhaps Maxim himself. He refers to the amateurs with the derogatory term 'the small boys in radio', and remembers that when he asked them how they enforced waveband assignments in order to prevent interference they replied: "we just take the fellow out and beat him up."[70] Maxim in contrast is trying to portray the organizaiton as relying on professionalism, working around the clock and apealing to the masses. The process of meaning making extends both into the organization and outside it, with statements like the one above. During 1916 and early 1917 the meanings and the workings of the ARRL were being debated, but soon an external event took precedence.

[69] I could not find reliable statistics, but from the different articles and pictures in all the source material I reviewed, it is evident that ARRL membership consisted primarily of young and middle-aged, educated, White men.
[70] Jesse Walker, *Rebels on the Air: An Alternative History of Radio in America* (New York, NY: New York University Press, 2001), 23.

The ARRL in World War I

On April 2, 1917, President Wilson addressed a special session of Congress and delivered his War Message.[71] Four days later, Congress overwhelmingly passed the War Resolution, which brought the United States into the Great War. The 1912 Radio Act gave the President permission to shut down radio stations "in time of war." With the War Resolution, the Navy was finally able to take control over radio. Despite the ARRL's suggestions that in the case that the U.S. formally entered the conflict amateurs should be employed as part of the war effort while maintaining their relay network structure in tact, or at least be allowed to keep their receivers operational in listening mode, the President Wilson signed an executive order, closing most radio stations not needed by the U.S. Government. The official rationale stated that radio communications could be used by the enemy in getting information on naval routes and for propaganda, and that the solution was to maintain radio silence other than for Navy operations. As noted above, the Navy thought that it should control radio communication even in times of peace, and I interpret this closing down of amateur radio as the exploitation of an opportunity to practice the policy the Navy had advocated for almost two decades.

Silencing amateur radio can be seen as a lesser evil for amateur radio considering the fact that just a few days after the declaration of war, on April 9, there were calls in the House of representatives to mandate all radio stations and equipment, to be turned over to the Navy.[72] Naturally the entire radio world protested this proposal as death to amateur and commercial radio. The House committee gave the stakeholders an opportunity to express their views and Maxim traveled to Washington

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[71] Woodrow Wilson, "War Messages Address before 65th Cong., 1st Sess. Senate," (Washington, D.C.: Government Printing Office, 1917).
[72] 65th Cong., H.R. 2753

to represent the ARRL.[73] Unlike the hearings in 1912, when amateurs were only represented by private individuals or local radio clubs, the situation now proved that organized amateurs were not only a relevant social group in their own eyes, but also in the eyes of the legislature. The proposed bill died in committee hearings, and the risk of amateurs surrendering their equipment was abated.

A few days later, amateurs who read QST received a letter from the Navy's district communication superintendent ordering "the immediate closing of all stations of radio communications, both transmitting and receiving."[74] The letter further instructed that "antennae and all aerial wires be immediately lowered and all radio apparatus... be rendered inoperative."[75] With the letter was a blank form to be returned signed to the Navy, acknowledging compliance, and a threat that non-compliance will be treated harshly. In most amateur communities, amateurs complied swiftly with the Navy's ban and in those rare instances where some hams tried to keep the operations going, the Navy reacted quickly. In Buffalo, NY, for example, the authorities set up a radio receiving station on town hall, listening to any violations and arresting amateurs that kept their equipment going.[76]

The Navy realized soon however that the amateurs were useful in another way; amateurs possessed the know-how that could be easily used in military operations. To try and tap into amateur talent, the Navy summoned Maxim to the Navy Yard in Brooklyn, and asked for his assistance in recruiting thousands of amateurs.[77] In the few days that followed, announcements went over the air to the few stations that were still in operation, and a few weeks later, in its May 1917 issue, *QST* published a call for recruitment along with empty enlisting forms encouraging hams to

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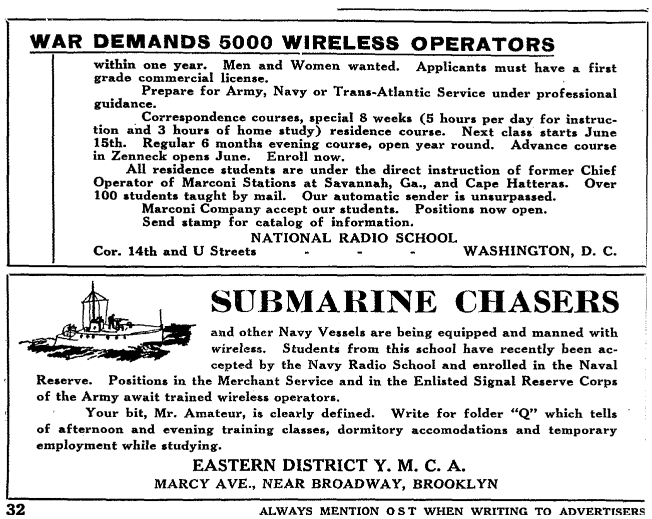
[73] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 51.
[74] Reprinted in "War!," *QST* 17, no. 5 (1917).
[75] Ibid.
[76] Ibid.
[77] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 52.

enlist in the Navy.[78] The call was successful and thousands of amateurs signed up. In the following few months, *QST* also published ads promoting commercial radio schools. These organizations started within the frame of commercial radio operators and with their cooperation. Commercial operators, like the Marconi company, were constantly expanding and needed fresh personnel that newly established radio school provided. When the war started, the radio schools stood up to the task of helping the Navy to train its personnel too (Figure 4-2).



WAR DEMANDS 5000 WIRELESS OPERATORS

within one year. Men and Women wanted. Applicants must have a first grade commercial license.

Prepare for Army, Navy or Trans-Atlantic Service under professional guidance.

Correspondence courses, special 8 weeks (5 hours per day for instruction and 3 hours of home study) residence course. Next class starts June 15th. Regular 6 months evening course, open year round. Advance course in Zenneck opens June. Enroll now.

All residence students are under the direct instruction of former Chief Operator of Marconi Stations at Savannah, Ga., and Cape Hatteras. Over 100 students taught by mail. Our automatic sender is unsurpassed.

Marconi Company accept our students. Positions now open.

Send stamp for catalog of information.

NATIONAL RADIO SCHOOL

Cor. 14th and U Streets - - - WASHINGTON, D. C.

SUBMARINE CHASERS

and other Navy Vessels are being equipped and manned with wireless. Students from this school have recently been accepted by the Navy Radio School and enrolled in the Naval Reserve. Positions in the Merchant Service and in the Enlisted Signal Reserve Corps of the Army await trained wireless operators.

Your bit, Mr. Amateur, is clearly defined. Write for folder "Q" which tells of afternoon and evening training classes, dormitory accomodations and temporary employment while studying.

EASTERN DISTRICT Y. M. C. A.

MARCY AVE., NEAR BROADWAY, BROOKLYN

32 ALWAYS MENTION QST WHEN WRITING TO ADVERTISERS

Figure 4-2: Ads calling amateurs to enlist in Radio School, 1917.[79]

While the ARRL encouraged hams to help their country, it also tried to keep itself alive. The ARRL's directors, first and foremost Tuska who was also the editor of *QST,* understood that now that the airwaves were silent hams lost both their relay mission and their primary means of communication with one another. The public lost

[78] "Wanted by Uncle Sam: 2000 Radio Amateurs," *QST* 17, no. 7 (1917).

[79] Source: *QST*, July 1917, 32

one of its key means of maintenance. The league faced an enormous problem of how to keep up its tune when in fact it was forced to be silent. The proposed solution was to ask members to support the continued publication of *QST*. Tuska published an editorial where he wrote:

> …if there is one thing which we of the ARRL need, it is that our QST be kept going during the war. It is the only thing we have which binds us together. The air is silent these days and most of us have almost forgotten what a signal sounds like. If we had no means of communicating with each other, it would be impossible to hold our organization together. It would be like a chain of sand.[80]

Tuska called members to keep paying their dues and, anticipating his own draft, also tried soliciting help. These efforts allowed publishing a few more issues but when Tuska joined the Navy to oversee radio operator training, publication of *QST* ceased from September 1917 until April 1919. During that period, amateur radio was non-existent. Many of the amateurs joined the military, where their radio skills were in great demand, and arguably helped the U.S. and its allies achieve military victory in the seas and on land.[81]

ARRL after WWI - the broadcast boom and an end of an era for amateur radio

In November 1918 an armistice was signed between the allies and Germany, and amateurs expected to rapidly get back on the air, but the Navy still wanted control. Some members of Congress wanted to use the war's positive experience with radio to finally justify handing control over wireless to the Navy and introduced bill proposals to that effect to the House and Senate.[82] The ARRL quickly organized to stop these

[80] "Help Keep Qst Together," *QST* 17, no. 6 (1917).
[81] White quotes multiple sources showing how wireless technology rapidly became essential for both ground warfare and naval operations. See White, *United States Early Radio History* ([cited 12/04/08]). Ch. 13.
[82] H.R. 13159, and S. 5038. See DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 55.

new regulatory attempts. Maxim traveled once more to Washington to the committee hearings, and the ARRL rallied hams that were at home and the families of those that were still in service to write letters to their congressmen. Thousands of such letters were received, and the bill was halted in committee. *QST* was quick to remind ARRL members again the power of their organization.[83] But the Navy still didn't give up and proposed that it would at least gain control over oceanic and international radio. The Secretary of the Navy, pushed the Senate in this direction through the summer of 1919.[84] In addition the Navy was active in trying to advance the 1919 Radio Protocol, a revision of the 1912 London convention. Again the amateur and commercial interests blocked these initiatives. But even after all this, the Navy wouldn't let go. Secretary Daniels did not want to lift the ban on amateur stations, which were still under his control. The ARRL understood that it would have to fight the Navy in Congress for it to cede control. *QST* tells the story of how Representative Green, a member of the Committee on Merchant Marine and Fisheries and a supporter of amateur radio, introduced a resolution to the committee to query the secretary of Navy why the ban had not been lifted. When that query went unanswered for a month, Greene introduced a house joint resolution to direct the secretary of Navy to remove the ban. This time the Navy realized it could no longer justify its control, and on September 26th 1919, amateurs were finally permitted on the air again.[85]

The Great War was a turning point in amateur radio's history from a different perspective. After the war, and due in large part to significant progress that the war efforts contributed to radio's development, broadcasters would redefine radio. From the technical perspective, the most important development was the perfection of voice

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[83] Ibid.
[84] "The Amateur Situation," *QST* 19, no. 9 (1919).
[85] "Daniels Only Knows," *QST* 19, no. 10 (1919). See also DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 58.

communication over wireless, also known as radiotelephony. I will not repeat here the story of the social construction of American broadcasting, but I shall look at how the stabilization of the broadcasting model can be seen as accelerating the closure of amateur radio's meaning.[86]

In her account, Douglas shows how at the front, the war demonstrated novel uses of radio, while on the home-front it accelerated the consolidation of the market by companies like AT&T, GE, and Westinghouse. These incumbents paid attention to wireless before the war, not willing to let Marconi and other radio operators jeopardize their successful land-communication business models. AT&T, especially, was an early experimenter with what was then known as the radiophone. DeForest experimented with voice transmissions as early as 1910, but only through the war experience did people realize the feasibility of large-scale wireless voice communication.

In 1919, when the Navy allowed civilian communication again, amateurs were quick to experiment with the new improvements. Among these experimenters was Frank Conrad, an amateur who, during the war, oversaw Westinghouse's manufacturing of portable radio transmitters for the army signal corps. After the war, Conrad returned to operating his radio station 8XK, from Pittsburgh, and was featured in the September issue of the 1920 volume of *QST* as a pioneer.[87] *QST* did not pay much attention to Conrad's fascination with voice transmissions, but two months later, on November 2, the day on which Warren G. Harding won the U.S. presidential election with a landslide, Conrad started commercial broadcasting. From a newly established station, KDKA, instead of the usual dots and dashes Conrad reported the elections' results with his voice and even music in the background. This was not the

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[86] The summary of the story is given in Chapter 8 of Douglas, *Inventing American Broadcasting, 1899-1922*, 268.
[87] "Amateur Radio Stations - 8xk, Pittsburgh, Pa," *QST* 20, no. 9 (1920).

first time voice and music had been broadcasted. Frank King, a ham from the Radio Club of America experimented with voice transmissions already in 1911, and the *Detroit News*, who operated WWJ, claims to have played music during the summer of 1911 and thus becoming the world's first broadcast station. However, Westinghouse's station was potentially the first to spur the group of radio listeners as such. Unlike amateurs, listeners were people who would buy a radio *receiver* for the sole purpose of receiving transmissions; they were the harbinger of what today many take for granted, the mass media audience.[88] How this came to be is related to Conrad's practice from earlier that summer to 'broadcast' concerts off his phonograph on Saturdays, alerting his amateur friends who would tune in. After receiving fan mail from listeners, Conrad moved to a daily broadcast schedule. By May 1920, a local department store manager who had heard of Conrad's concert series put up an ad in the local paper announcing that he had started selling $10 receivers capable of tuning in to the wondrous broadcast.[89] Reading the ad in the paper, and learning more of his employee's broadcast endeavor, Harry Davis, a vice president in Westinghouse, realized the commercial potential entailed in this new use of radio. Conceiving of radio as a point-to-point communication device for the limited amateur market was nothing compared to the potential of a general market for broadcast audiences. Davis convinced Westinghouse to allow Conrad to build a powerful station at the Westinghouse plant and to manufacture low cost radio receivers. A few thousand devices were sold in the Pittsburgh area in a short while, starting what would soon become a national phenomenon, later known as the broadcast boom.[90] Commercial and amateur stations

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[88] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 70.
[89] Douglas, *Inventing American Broadcasting, 1899-1922*, 299.
[90] Ibid., 300.

mushroomed overnight. By January 1922 there were 1,200 stations around the country, owned both by commercial operators and by amateurs.[91]

We can clearly see how radio, which up to that point was a two-way communication technology, was rapidly gaining an additional meaning within a new technological frame, that of broadcasting-listening. The new group of listeners was comprised not of the technically savvy, self-taught experimenters of the prior decades, but, rather, of men and women of some affluence, who could afford to pay for the new technology. The rate of change is astonishing. Within less than two years, tens of thousands of listeners joined the radio circle. Identifying the trend, in mid 1921 the ARRL started calling its practice ‘Citizen Radio’, rather than ‘Amateur radio’. In December 1921, for example, *QST* added a new section to its monthly publication called “With the radiophone folks”[92] (later renamed “With our radiophone listeners”), which addressed the interests of listeners and listed local broadcasters. The section called hams to alert friends to the new listings, and encourage them to subscribe to *QST*. Following this attempt, *QST’s* circulation doubled in one month. Listeners were being recognized as a group, and it was growing rapidly. In July 1922, DeForest estimated that there were more than a million listeners and that soon there would be five million.[93]

Clearly, the ARRL was wary about fully embracing the new medium, since it jeopardized the original meaning of its existence, the relay work. The December 1921 editorial of *QST* reads:

> The prime aim of our ARRL is the furthering of Citizen Radio and we look forward to that day when every home will have its radio installation--when powerful central stations will broadcast news, concerts, lectures, entertainments, and everyone may get them without

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[91] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 75.
[92] "With Our Radiotelephone Listeners," *QST* 22, no. 7 (1922).
[93] Ibid.

> stirring from his living room. That day is coming...[however] for the handling of relay traffic the [radio]telephone so far has failed miserably and it isn't at all likely that it will ever come into an general use for that purpose, mainly for the big reason that any telephone set is capable of covering three or four times it's phone range when used for straight [radio]telegraphy[94]

This partial embrace of the new technological frame can be better understood while considering the technical problems that arose. Before the broadcast boom some ten thousand amateur stations shared their portion of the airwaves using the self-regulatory modes I discussed earlier. Interference posed a problem but the situation was manageable. After the broadcast boom started, the situation changed. Listeners as well as broadcasters were unwilling to tolerate the interference levels that were considered normal for ham communications, and as a result they grew resentful and sought redress through further legal regulation. The ARRL realized this danger, and opened a publicity department and made a plan for national advocacy that would educate the general public about the importance of amateur radio.[95] Several commercial manufactures tried to profit from solving the problems via technical means, and started advertising marketing equipment for either listeners or hams that would decrease interference.[96]

In January 1922, the Department of Commerce intervened and introduced broadcast station licensing requirements, and temporarily assigned broadcasters the spectrum of 360 meters, offering some relief.[97] At the end of February, Secretary Hoover convened the first National Radio Conference, inviting all stakeholders to speak in Washington. It was established early on that the conflict was not between amateurs and broadcasters—as mentioned earlier, some amateurs were broadcasters

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[94] "The Radiophone," *QST* 22, no. 12 (1921).
[95] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 75.
[96] "Advertising: The Broadcast Boom," in *Fifty Years of A.R.R.L.: A Reprint of Historical Articles from the 1964 Issues of Qst* (American Radio Relay League, 1981), 47-48.
[97] DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 75.

themselves—but, rather, between commercial and amateur interests. This was a new situation because of the fact that during previous regulatory debates amateurs were much aligned with the commercial operators in their struggles against the Navy. The result of the conference was a set of recommended regulations that separated the powers by splitting the spectrum. Broadcast was assigned the range form 210 to 435 meters, while amateurs stayed under 200 meters. The final report also included a definition of amateurs that the ARRL pushed: "An amateur is one who operates a radio station, transmitting or receiving, or both without pay or commercial gain, merely for personal interest or in connection to an organization of like interest."[98] This definition and spectral division allowed the ARRL to re-establish the primary meaning of amateur radio as it had always promoted—a free medium for point to point communication. From that moment on, broadcasters focused on developing the advertising-based business models that underwrite what became the basis for the American mass media. The ARRL, on the other hand, was able to focus on what they were trying to do for the previous decade, namely perfecting their network for its use as social communications means as wells as an emergency communication network. Notabely, the relay mission was not as important anymore. After the war new technologies, including vacuum tubes and continuous wave (C.W.) transmissions had been invented, stratospheric reflection had been explored, and short-wave communication on low power was not limited anymore to short distances. Under those terms, amateur radio achieved relative closure. The key problem as the ARRL perceived it—threats of being kicked off the spectrum—was solved. In the following decades, the ARRL would see ups and downs, but from 1922 until today it remained

[98] Ibid., 77.

the largest amateur radio organization, dedicated to the perfection of point-to-point radio communications.

Communities and the social construction of affordances

The ARRL's story exemplifies many of the tensions between enclosure and openness that I started outlining in the case of FOSS (and that I will further explore in the cases of the GOC and BIOS). In all the case studies incumbents and stakeholders who favor proprietary systems attempt to regulate the open alternatives by technological, legal, social and economic means. In this case these attempts resulted in battles for the control over essential resources like the spectrum and fights over key patents. The lobbying efforts by commercial interests and the Navy that led to the Radio Act of 1912 allocated to radio hams a then unfavorable section of the radio spectrum, 200 meters and below, which was believed at the time to be completely useless for long distance communications. To achieve long-distance networking, hams had to develop schemes for collaboration that could overcome this technical impediment, and in that respect I interpret the founding of the ARRL as a response to the Radio Act of 1912. By the early 1920s, techniques for short-wave communication were developed, and the original problem was overcome by technical means, but the new community had already been created. The perceived material constraints of a technology were instrumental in coalescing new social groups.

While SCOT clearly recognizes that social groups change over time and in direct co-evolution with technology, a question that comes up is to what degree the two are linked. Clearly materiality matters, and pushing amateurs to the end of the spectrum imposed new limitations on their previous activities as individuals and as a group. As a way of helping to think about the role of materiality here, and a way to reconcile Lessig's model with SCOT, I introduce the concept of technological affordances, that expands SCOT in important ways.

Affordance was a term originally coined by perceptual psychologists and used in the fields of cognitive psychology, environmental psychology, industrial design, and human-computer interaction. The term was first introduced by psychologist James J. Gibson in 1966, then explored more fully in *The Ecological Approach to Visual Perception*[99] where Gibson investigates affordances for action (i.e. the empty space in a door-path affords walking through the door). Donald Norman further developed the concept in his book *The Psychology of Everyday Things.*[100] His definition of an affordance is the design aspect of an object or a system that suggests how the object can and should be used: "…the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used. A chair affords ('is for') support and, therefore, affords sitting."[101]

However, this definition of affordance is too tied to the psychological literature and assumes too essentialist a use of a product for my purposes. I want to make the notion of "affordance" consistent with the sociology of technology. It is clear that systems' users and participants come up with new and unexpected uses of technology and that it is problematic to read off a definitive or 'best-use' from the design of an artifact. How a chair will actually be used depends on the context it is used in – for example some chairs may never be sat in and are always used as foot rests. Furthermore, what a technology is good for, or what can be done with it, is in itself a process of social construction. Looking at the artifact alone cannot suffice for fully

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[99] J. Gibson, *The Ecological Approach to Visual Perception* (Hillsdale, NJ: Lawrence Erlbaum, 1979).
[100] Donald A. Norman, *The Psychology of Everyday Things* (New York, NY: Basic Books, 1988).
[101] Ibid., p. 9

analyzing affordances. The social, historical, economic, and legal contexts are decisive in shaping the ways that technologies are interpreted.

An instructive example is that of the early French videotex system known as Minitel.[102] This is often seen as a precursor to the Internet and enabled French users to exchange and post information with each other from their home terminals about restaurants and other products and services, famously including sexual services. The rapid take-up of the interactivity dimension of Minitel was something that completely surprised the engineers who had designed the system. They had included interactivity because it was technically feasible to do so but they did not expect it to become the defining feature of Minitel. Other videotex services like the UK British Telecom system, Prestell, had no such interactivity and users were limited to broadcast announcements about TV programs and services, posted from only a few central locations. Thinking of this in terms of affordances, I can say that use is constrained by the affordances the technology offers but that users can resist, alter, and work within the constraints, changing the actual use of the technology.[103] For example, the affordance of a chair allows it to become a foot-rest but does not allow it, to my knowledge, to become a Minitel terminal.[104] One should be careful to distinguish physical limitations on affordances from social (including political, cultural and economic) limitations. For example, the physical limitation on the affordance of communication at a certain wavelength does not constrain the type of speech (an amateur can be rude, not follow the rules, intercept others, etc) but the social limitation

[102] V Schneider et al., "The Dynamics of Videotex Development in Britain, France and Germany: A Cross-National Comparison," *European Journal of Communication* 6 (1991).
[103] A related notion here is Madeline Akrich's notion of a technological "script". As with a literary script, designers try and designate particular patterns of use that are "scripted" into the technology. See Madeline Akrich, "The De-Scription of Technical Objects," in *Shaping Technology/Building Society-Studies in Sociotechnical Change*, ed. Wiebe Bijker and John Law (Cambridge, MA: MIT Press, 1992).
[104] This issue is much debated within the field of Science and Technology Studies. For instance see K. Grint and S.W. Woolgar, "Computers, Guns and Roses: What's Social About Being Shot?," *Science, Technology & Human Values* 17 (1992).

does constrain behavior.[105] In summary, I want to suggest that affordances themselves are socially constructed. Using this new terminology, I can now ask which new affordances the relay system offered, and how those are related to the modes of regulation through code, law, markets, and norms.

The first affordance I observe is the perceived technical limitation of communication in short wavelength. As discussed above, with the knowledge and equipment available to hams before that war, operation at wavelengths under 200 meters and power under 1KW posed strict limitations on the maximum range of any single transmission. But Morse code transmission afforded the ability to be stored and then forwarded. As discussed, the system could be set up in a way that three or more stations form a relay. In other words, a social structure was set up that enabled to overcome the limitations and route around them. Any single point-to-point transmission was limited, but the system as a whole now afforded long-distance communication. As I demonstrated above, the ARRL was built with the 'relay mission' serving as its main scaffolding. For Maxim, the notion that amateurs can come together to form a relay network was an essential part of the plan of bringing amateurs together, and increasing their value in the eyes of the government. Ostensibly, point-to-point communication over short distances was not enough to justify the amateurs demand for the spectrum. The relay scheme increased the value of the network and was the basis of the claims that amateurs can offer a valuable service to the nation.[106]

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[105] For a nuanced study of how social and technical processes work together to enable new sorts of affordances in online newspapers, see Pablo Boczkowski, J.,, *Digitizing the News: Innovation in Online Newspapers,* (Cambridge, MA: MIT Press, 2004). Hutchby uses of the notion of affordances in discussing how an interactionist approach towards telephone conversations can be integrated with the sociology of technology, see I. Hutchby, *Conversation and Technology* (Cambridge, MA: Polity Press, 2001).

[106] "Amateur Wireless Crosses Continent; American Relay League Sending Messages from New York to Los Angeles. Ready for War Service.."

A second affordance of the relay league was the reduction in cost of sending messages. At a time when a telegraph message cost up to $1 for ten words,[107] there was constant pressure from the public to reduce prices.[108] Using the ARRL's relays, hams were able to send and receive messages almost for free.[109] One reason for this cost reduction was that the amateurs that relayed the messages were all volunteers. The other reason was that there was nobody trying to profit or to return investments in expensive infrastructure. As I outlined in the case of FOSS and will explore in following chapters in the cases of the GOC and BIOS, in systems that are open to volunteer participation the freedom to operate is tightly tied to a reduction in operational costs. As I outlined in Chapter 3, in the case of **free** and open source software, the distinction between freedom as freedom from cost and freedom as freedom from constraints is known as the free beer vs. free speech interpretations of freedom. In this case, radio's appeal as a cheap, if not free, means of communication for personal use is clearly compounded with other meanings of freedoms, like freedom from the government or from the need to contract with a corporation. This conflation of meanings is a commonality that is apparent in the other case studies as well. It also highlights the important role that volunteers serve as free laborers. This, I will demonstrate, came to an extreme in the case of the GOC in which the government calculated that it simply had no budget to pay for the skywatching mission it wanted to accomplish. In the language of affordances, the ARRL affords cheap communications. This affordance is a combination of technical capabilities that allow setting up a node on the relay network without a big capital expenditure and a social structure that prompts hams to work together and relay each others messages. I have expanded

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[107] "Widespread Cut in Telegraph Tools; a Charge of Thirty Cents Instead of Forty, to Be Made between Certain Zones.," *The New York Times*, June 27 1912.
[108] "Cable Reductions Start Rumors of a Rate War," *The New York Times*, January 7 1912.
[109] William Perry interview. Clearly, there was cost associated with setting up a station, but that cost did not incur to the people who asked hams to convey their messages.

elsewhere on a much later case, about eighty years later, where similar principles allowed the emergence of peer-to-peer file sharing networks like Napster, which afforded massive file sharing and copyright infringement of music and thereby changed the economics of digital music.[110]

A third affordance of the relay system was the ability to maintain the community using the same technology that helped bring it into being. For its ongoing success, the ARRL needed to instill a sense of mission and partnership in its members, an accomplishment that was pursued during formal and informal gatherings, but first and foremost over the air. The way that the system was set up, as a relay network, embedded in its very structure the notion of a community without which the system would not exist. The reverse is also true: the community was itself based on principles that brought relay into being. Unlike in the case of software, which under some conditions can be an individualistic hobby, radio relay is an activity that could only be pursued by a group. To this end, the system was set up with strong norms that regulated the community's activities. This affordance is notable because setting up radio relays allowed the hams to get directly in touch with one another using the same technology they were exploring. The same is not true for all types of networks, which require auxiliary communication mechanisms. In the case of the GOC, for example, radio communication among the observation posts had to adhere to strict codes (see Chapter 5). In the ARRL, in contrast, 'rag-chewing' was a common activity. As I showed earlier, building the community over the air was one mechanism. Of course, it was not the only mechanism. *QST* was another primary mechanism for helping the community come into being, and as I discussed earlier, hams often met in person, organized clubs, exchanged and sold equipment, and other such activities. In Chapter

[110] David, "On Source Scapes and Filescapes: Towards a Critique of the Political Economy of Free and Open Source Software".

7, I discuss these activities in the context of the ideology of openness, showing how such practices become part of the apparatus that sets the imaginary relationship of individuals to their real conditions of existence. Importantly, the affordance of building the community using the same technology being built ads a recursive level to the notion of community building, and shows the important connections between community and technology in these systems.

Conclusion

In this chapter I have demonstrated how the ARRL coalesced as a participatory information network, solving challenges pertaining to collaboration and participation, and fighting off government regulation. I showed how the actors' negotiated the meaning of the technology at hand, attempting to influence government regulation of a new technology during the process of its stabilization. This story demonstrates the reoccurring tension between regulation by law and regulation by code that applies to all other case studies, especially to FOSS. It also brings out the tension between the principles of self-selection and central, hierarchical control. On all these dimensions, the ARRL serves as a historical mirror for FOSS, demonstrating how regulation is changed by and changes social structures. Overall this chapter contributes to my argument by showing how open systems are never fully open and how they deal with questions of motivation and issues of coordination and cooperation by finding a balance between hierarchical control and openness to participation.

A recurring question in all the case studies is the prospect of stability for system motivated by diverse individuals who are not paid to do their job, and who cannot be commanded to participate. The studies I surveyed in Chapter 2 asked why volunteers devote their time, effort, and resources to projects in which their personal gain is not immediate. A follow on question is not why people participate in these open systems, but what happens when they do. As this case shows, the ARRL counted among its ranks at one and the same time young adults looking to buttress their technical identity,[111] older men trying to escape from their daily familial chores, experimenters from other fields that were looking for technical challenges, and many more types of individuals. For the system as a whole, however, this diversity doesn't matter, so long as it has built-in structures that allow this collaboration to produce stable artifacts. In the case of the ARRL the structures were a monthly publication and an elaborate plan for cooperation and coordination; the artifacts were person-to-person messages. The ARRL shows that the motivation for collaboration becomes less important as long as the system can aggregate the collaborators' work. In the cases of FOSS and BIOS, the artifacts produced could be a line of code, a cell line, a drought-resistant crop, or a software bug report; who produced each part, who contributed what, and what their motivation was become less important questions if all of the system's parts can be combined in a coherent way and if the collaboration can consistently produce all the necessary parts. Surprisingly perhaps, in order to overcome problems of large-scale collaboration effectively, massive participation is needed so that the importance of individual motivation will decrease. One area where this is significant for the ARRL's development was the inclusion of women. For many women participating in a wireless club was a way to train themselves, and later work for firms. Especially during the war years, many women have been trained by the Navy and have joined the amateur networks. The man were generally welcoming to this trend, and *QST*, even had an editorial titled "the ladies are coming" in which it

[111] In the sense of Haring, "The "Freer Men" of Ham Radio: How a Technical Hobby Provided Social and Spatial Distance."

called hams to be mindful of their language in the presence of hams of the 'fairer sex'.[112]

As I outlined in the introduction, systems that are open to volunteer participation face challenges when managing participation, collaboration, cooperation, coordination, sharing, and distribution. The need to overcome these issues is clearly not exclusive to these systems. Collaboration is a basic element of society and is the founding rationale of any social contract. Collaboration is expressed in any coordinated military action and in many industrial models of organization, from the assembly line to the production of science. However, collaboration of the sort seen in the ARRL is different than that of managerial organizations like firms or armies in several important respects. Unlike in a managerial system where the worker or soldier performs what he or she is told and coordination is managed in a tightly controlled top-down manner, in open systems free agents have greater latitude in making their own choices. Tasks are managed by finding balance between a top-down direction and a bottom-up style of execution. Deciding where and when to operate a ground radio relay station, for how many hours a day, or using what equipment, were all decisions that individual hams could make, but they were still constrained by a larger set of decisions that came from the top-down. While Maxim was designing the trunk lines during April 1916, QST reported that: "headquarters has received a large number of letters form the various parts of the country suggesting changes in the cities through which the different Trunk Lines are supposed to pass. Many of the suggestions made are distinct improvements over the original layout made by Mr. Maxim."[113] At the same time, ARRL headquarters did exert a level of control by appointing Trunk Line

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[112] Michele Hilmes, *Radio Voices: American Broadcasting, 1922-1952* (Minneapolis: University of Minnesota Press, 1997), 133-34.
[113] "Trunk Line Managers Appointed," *QST*, April 1916.

managers who enforced a strict set of tests on the deployment of the relays every Monday and Thursday.[114] By selecting key relay stations and designating trunk lines, the ARRL was able to keep many of the flexibilities in the edges of its network without compromising its function. In the language of affordances, the system afforded flexibility on the operation of each individual node, provided that the basic skeleton was kept intact.

A parallel mechanism is apparent in the operation of FOSS projects. In that case the core developers, who are at the center of the 'onion', have control over what eventually enters the stable code release. Developers that fix bugs or develop features are subject to the control of a release manager. There is a balance between the processes of self-selection of tasks (i.e. which bug to fix, or feature to develop) and centralized, hierarchical control. In some systems, like the one used on SourceForge, that balance is sought using technical means such as a system for 'voting' on bugs, which allows the users of a particular software applications to vote on what bugs they think need to receive the most attention.

A different approach to overcoming problems of coordination, collaboration and cooperation is the pricing system. In a market-based system, free agents collaborate and cooperate by signaling to one another through the price system. Rational profit-maximizing actors select their strategies in response to other actors' behaviors expressed through price signals (i.e. the willingness of other actors to sell or buy certain goods and services at certain prices). However, as this case demonstrates, unlike in market-driven systems, in systems like the ARRL, the pricing system plays little role in coordinating the actions of many participants. Participatory information networks like the ARRL rely not on price signaling but rather on the participants'

[114] Ibid.

sense of self-worthiness, which provides inherent motivation for participation. The benefit for volunteers is bolstering of their identities and participation in a community of like-minded individuals, while in the process regaining control over the modes of meaning-making in their lives.[115] To a large extent, this is a recurring theme in all the systems I investigate. The next chapter tells the story of the Ground Observer Corps, where the same challenges have to be solved in a different context.

[115] As discussed in Chapter 2, Haring discusses the way in which for hams participation in these communities focused on building their technical identity. SeeHaring, "The "Freer Men" of Ham Radio: How a Technical Hobby Provided Social and Spatial Distance." see also Dunbar-Hester, "Geeks, Meta-Geeks, and Gender Trouble: Activism, Identity, and Low Power Fm Radio."

CHAPTER 5:

THE GROUND OBSERVER CORPS -

OPENNESS TO PATICIPATION IN THE CLOSED WORLD

> "I know of no instance in our history when a military organization was so dependent upon the full cooperation of thousands of Americans outside the military."
>
> General Benjamin Chidlaw, head of Air Defense Command, 1952[1]

Introduction

This chapter investigates the case of the Ground Observer Corps (GOC), a paramilitary organization that operated in the northern part of the United States throughout the 1950s. This story begins in 1949, when, following a surprise detonation of an atomic bomb, the Soviet specter began to haunt America's dreams. In the face of a potential nuclear air invasion, lacking sufficient technology, funding, and manpower, the Air Force resorted to volunteers for protecting the nation's borders.[2] Hundreds of thousands of volunteer observers were trained to use photographic guides and silhouette keys for identifying American, Soviet, British and French aircraft. Experiments in October 1951 tested the readiness of 14,000 partially manned lookout stations, showing mixed results. Subsequently the operation was expanded to include more observation posts and operate them on a round-the-clock basis.[3] Over the next six years, under codename 'Operation Skywatch' more than 800,000 volunteers stood

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[1] Benjamin W. Chidlaw, "The Invaluable Contribution," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 1 (1952).

[2] Employing ground observers, as an air defense strategy, was proven and tested in England during WWII. In the U.S., close to the end of WWII, about 1.5 million civilian volunteers were enrolled by the Army Air Force to man 14,000 observation posts positioned along the nation's coasts. With the declining threat to America from German and Japanese Air Forces, the Army Air Force disestablished the GOC in 1944. See Ibid.

[3] Kenneth Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense 1945-1960* (Washington, D.C.: Office of Air Force History, United States Air Force, 1991), 157-59.

alternating shifts at 16,000 observation posts and 73 filter centers, which were spread from coast to coast. The GOC operated until the end of 1958 when the problem of low-flying airplane detection was considered to be solved by new short-range AN/FPS-14 radars that were deployed as part of the Distant Early Warning (DEW) line and Mid-Canada radar line.[4] The GOC was disestablished on January 31, 1959 without ever spotting a single enemy airplane (for the simple fact that none ever came).

Like the other case studies, this case too offers testimony on the role of volunteers in building large and complex information networks. The chapter starts with a set of questions. How did it come to be that in the midst of the cold war, at the heart of one of the largest military efforts in history, the military turns to volunteers to complete an essential defense task? Who participated in this system and why? What were its operating principles? Are these comparable to the two earlier cases that I investigated? What are the continuities and discontinuities between this and earlier or later systems? In the following pages I will explain why and how the volunteer-based GOC became a key element in America's air-defense strategy. I will review the key events and developments and discuss the meanings that the GOC came to embody in the eyes of several relevant social groups. I will continue with a discussion about the ways in which the GOC dealt with problems of coordination, cooperation, distribution, and motivation, noting the important role that identity building played in GOC volunteers' recruitment efforts. The chapter suggests that the GOC is a hybrid open-closed system that on one hand was based on principles like volunteer work, self-help, self-selection of tasks, and grass-roots funding, while, on the other hand, resting on a skeleton of managerial and hierarchical governmental and military forms of control

[4] Ibid

and organization. To this extent I view the GOC as an open system operating within the environment that Paul Edwards dubbed 'the closed world.'[5] Exploring the tension between the GOC and its environment will help me drive the story forward and investigate the other two themes of this work, contributing to SCOT and outlining the implications for democracy.

I expand on Julian Kilker's work that augmented SCOT with concepts from identity theory. I argue that in order to explain an information system like the GOC, SCOT needs to pay special attention to users' identities as primary categories in our explanations. Whereas SCOT would treat many of the volunteers as social groups that relate to the technology through the problems it creates or solves, identity theory suggests that individual motivations play an equally determining role. When individuals cooperate in a network structures their individual identity-building strategies amount to something larger. I will argue that the ability of diversely motivated individuals to cooperate in achieving a common goal was a characteristic of this system that at one and the same time brought community together and relied on communities for its own existence.

Lastly, expanding on the meaning of open systems to democratic culture, I will argue that the GOC's historical significance stems not from its debatable direct contribution to America's air defense, but from its ability to allow citizens to engage in what they believed was a modern manifestation of civic duties and thus enhance their civic identities. To this end, openness to volunteer participation served to increase democratic culture in ways that are quite similar to how such openness works in other domains. I will return to this point in the next chapter as well.

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[5] Edwards, *The Closed World : Computers and the Politics of Discourse in Cold War America*.

Background: Air Defense at the dawn of the cold war

On September 23, 1949, president Harry Truman made the following announcement: “I believe the American people, to the fullest extent consistent with the national security, are entitled to be informed of all developments in the field of atomic energy; that is my reason for making public the following information. We have evidence that an atomic explosion occurred in the USSR.”[6] With this terse proclamation from the White House, delivered only four years after the first atomic bomb was dropped on Hiroshima and World War II ended with an overwhelming American victory, the citizens of the United States were informed of a new Atomic era. The announcement came after American airplanes sensed a nuclear explosion a few weeks earlier, years before U.S. intelligence had assessed the Soviets would gain nuclear capability. The public was well aware of the Soviets’ conventional military might, and thus, with Truman’s dramatic announcement, the semblance of invincibility puffed away together with the Soviet mushroom cloud and hopes for control and domination were replaced by fear and insecurity.[7]

Arguably, the Soviet experiment was the official opening shot for another global arms race; the surprise explosion would reverberate in the hallways of America’s powerhouses for decades to come. With America facing the Soviet Union as its new nuclear nemesis, the race was shifting into high gear. America realized that, perhaps for the first time since 1812 when it declared war on Britain, its sovereignty was put at risk, this time with a potential invasion, from the air. “There’s only one thing worse than one nation having the atomic bomb,” Nobel Prize-winning scientist

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[6] Harry S. Truman, "Atomic Explosion in the U.S.S.R.," (Washington, D.C.: Department of State Bulletin, 1949), 487.
[7] Laura McEnaaey, *Civil Defense Begins at Home: Militarization Meets Everyday Life in the Fifties* (Princeton, NJ: Princeton University Press, 2000), Ch. 1.

Harold Urey captured the situation in a famous statement, "That's two nations having it."[8]

This new situation resulted in two strategic developments in U.S. defense policy. The first was a concentrated effort to build an ultimate weapon, the hydrogen bomb, which, so it was believed, would allow the U.S. to regain its diplomatic advantage through military power and serve as a deterrent to any Soviet aggression as part of the new philosophy of Mutually Assured Destruction (MAD). The second, which is the main concern here, was a reorganization of air-defense along the nation's northern borders. This was a hurried attempt to increase security levels at key industrial areas and calm down the population. The reorganization was meant to ameliorate the state of the neglected air defense system, which had been kept to a bare-bones minimum during the preceding years.[9]

While the government was under pressure to react quickly, attempts to beef up air defense faced two sets of problems. The first was institutional; there was ample opposition from within the Air Force to any proposed changes to a years-long strategy that favored offense over defense. Radar defense doctrines, held back by advocates who considered strategic bombing to be the only key to breaking enemy production capacity and civilian morale, suffered from an institutionalized negative bias and constant lack of funding.[10] Arguably, this exact doctrine proved successful over German and Japanese skies, so convincing the old Army Air Force generals to adopt a new strategy was a slow process. The second impediment was technical: in the early 1950s radar technology, and more importantly communication technology able to

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[8] Urey won the Nobel Prize for Chemistry in 1934 for his discovery of deuterium, or heavy hydrogen, an important element in the development of the hydrogen bomb. Quoteed in Allan M. Winkler, *Life under a Cloud: American Anxiety About the Atom* (Champaign: Universit of Illinois Press, 1999), 68.
[9] Edwards, *The Closed World : Computers and the Politics of Discourse in Cold War America*, 86.
[10] David F. Winkler, *Searching the Skies: The Legacy of the United States Cold War Defense Radar Program* (United States Air Force Air Combat Command, 1997 [cited 06/07 2006]); available from http://www.fas.org/nuke/guide/usa/airdef/searching_the_skies.htm.

connect distributed radar systems, was not developed enough to facilitate the monitoring of the nation's lengthy borders over which the proverbial low flying aircrafts would emerge on their way to drop annihilating atomic bombs on American cities.

By 1958 the doctrinal barrier was overcome when new personnel took command of key Air Force positions. The technological barrier was overcome with the development of the appropriate technologies, mainly the Semi-Automatic Ground Environment (SAGE) project, which utilized a large-scale digital computer and later became a model for modern computing. While these changes were taking place a partial solution was readily available with the resurrection of the GOC.

The roots of the GOC can be traced to the beginning of WWII. Alarmed by the newfound power of air strikes, as made clear by the heavy tolls Britain was suffering from Germany's Luftwaffe, in 1940 the U.S. Army Air Force decided to establish the Air Defense Command (ADC).[11] The ADC's original mission was to test systems and formulate doctrine for America's air defense. A year later, before much in the way of air defense was done, the Japanese attack on Pearl Harbor, in December 1941, proved to any skeptics that indeed American territories were vulnerable to strikes from the air. The ADC's response included frenzied efforts to deploy interceptor squadrons and ninety-five radar stations along the East and West coasts,[12] as well as extending funding for academic research aimed at developing new radars. These efforts, however, were never tested in battle; soon thereafter the U.S. achieved control over the Pacific theater calming concerns about enemy bombings. By 1943 further allied victories rendered a surprise attack on U.S. soil improbable and air defense on the

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[11] Walter J. Boyne, "The Rise of Air Defense," *Airforce Magazine (Journal of the Air Force Association)* 82, no. 12 (1999).
[12] Ibid.

home front had been relegated to low priority. Consequently, the ADC was disestablished.[13]

WWII had barely ended when in less than 3 years the Soviet aerial threat became imminent. As a result, in 1946 the Army Air Force decided to re-establish the ADC, which now focused on planning air defense in the face of the Soviet threat. The ADC called for the establishment of a permanent network of 114 radars, a plan that was contested by other air force departments and contradicted recommendations by the RAND corporation, which advocated strong offence and a minimal air-defense.[14] At that point the ADC had a small budget and small workforce, and like other organizations within the Army Air Force, its top brass was waiting to see the results of a reorganization stemming from the National Security Act of 1947, which was about to separate the Air Force from the Army.[15] Later that year, however, with the deteriorating relationship with the Soviet Union in the background, political forces drove the ADC's ambitious plan forward. An internal history of the ADC documents that:

> On November 12, 1947, Secretary of Defense James V. Forrestal announced that planning was underway for a national early warning radar network. Nine days later, [Army Air Forces' Chief of Staff] General Spaatz approved the blueprint calling for a radar fence plan of 374 radar stations and 14 control centers to be built throughout the continental United States and an additional 37 stations and 4 control centers to be placed in Alaska. Called Project SUPREMACY, the plan predicted that with immediate funding, the system would be operational by mid-1953…Project SUPREMACY represented an enormous leap

[13] Ibid.
[14] Ibid.
[15] *Timeline of U.S. Diplomatic History: National Security Act of 1947* [Web] (Under Secretary for Public Diplomacy and Public Affairs > Bureau of Public Affairs > Office of the Historian, 2006 [cited 06/16 2006]); available from http://www.state.gov/r/pa/ho/time/cwr/17603.htm.

> from what existed at the end of 1947. At that time ADC operated only two radar stations.[16]

While full budgetary approval for SUPREMACY was being negotiated, in February 1948, there was a Communist coup in Czechoslovakia, the Communists were making way in China and the Air Force intelligence issued a warning stating that the Soviets were preparing to conduct a surprise attack. On March 27, 1948, General Spaatz, ordered the recently placed ADC radars at key locations, particularly at the Hanford, Washington nuclear facility, to enter round-the-clock operation. Due to insufficient personnel and material resources, 24-hours operations in the Northwest proved beyond ADCs capability.[17] The surprise Soviet strike never came, but the lesson was learned: in its current state, air defense was deficient. This realization was at the heart of the Air Force's appeal to a group of civilian volunteers to carry out such a critical mission.

In late 1948, the Air Force's reorganization materialized and as a result Major General Gordon P. Saville was appointed the commander of ADC. Saville made a name for himself as a forward thinker when he wrote the Air Force's handbook titled "Air Defense Doctrine" in 1941, where he presciently advocated and promoted growth of radar stations, ground observer corps, and control centers.[18] Saville was a pragmatist and he soon realized that, despite early support, a full implementation of SUPREMACY was unlikely due to budgetary constrains. Realizing that for full air-defense existing resources would have to be leveraged, he promoted three ideas: (1) a smaller system with fewer radars; (2) cooperation with Canada in which the U.S.

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[16] Winkler, *Searching the Skies: The Legacy of the United States Cold War Defense Radar Program* ([cited 12/04/08]).
[17] Ibid.
[18] Boyne, "The Rise of Air Defense."

helped in constructing, equipping, and operating some radar stations on the northern side of the U.S.-Canadian border; and (3) the re-establishment of the GOC.[19]

The ADC would have preferred a technical solution to trusting volunteers to do its job, but internal assessments showed that there was no other ways to achieve sufficient levels of defense.[20] Through the works of expert committees established to evaluate the problem, it became clear that existing radar technology could not seal off the border. The Valley committee at MIT concluded in 1950 that existing technologies could only detect 10% of threatening aircraft.[21] The predictions were corroborated two years later, in April 1952, when a false alarm in Alaska suggested that automatic detection and the launch of interceptor aircraft was not feasible with existing technology.[22] In contrast, the experience gained in WWII showed that human observers could provide an alternative. Seville's men believed that by employing human observers they would fulfill "the requirements for low altitude surveillance throughout a vital part of the nation… [by] strengthening many of the weaknesses in the radar network, since visual observers are effective in many cases where radar is of little or no aid."[23]

Simple calculations showed that the sheer amount of human observers necessary would require support from outside the Air Force's own personnel. The Air Force thus found itself dependent on the work of civilians. In the cover article of the

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[19] Winkler, *Searching the Skies: The Legacy of the United States Cold War Defense Radar Program* ([cited 12/04/08]).
[20] Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense 1945-1960*, 156.
[21] Valley was a renowned MIT scientist, and the committee that he headed was influential in shaping air-force strategy for many years later. See Winkler, *Searching the Skies: The Legacy of the United States Cold War Defense Radar Program* ([cited 12/04/08]). and Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense 1945-1960*, 144. See also Edwards, *The Closed World : Computers and the Politics of Discourse in Cold War America*, 9094.
[22] Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense 1945-1960*, 150.
[23] Ibid, p. 157

inaugural issue of *The Aircraft Flash,* the official magazine of the GOC that would be published several months later in 1952, General Benjamin Chidlaw, then head of the ADC, commented: "I know of no instance in our history when a military organization was so dependent upon the full cooperation of thousands of Americans outside the military."[24] While the *Aircraft Flash* was an internal publication and clearly had promotional motivations, as I discuss at length below, this statement seems to reflect the inconvenient truth that ADC was facing. Put in the terms that I introduced in the previous chapter, the state of the art of radar technology at the time did not afford a cost-effective option for achieving the task of low-flying aircraft detection. Chidlaw explains his perceptions as follows:

> There are two inherent limitations in radar. First is the tremendous cost of erecting and maintaining radar stations. To build an overlapping network of radar completely around the United States would impose a severe --perhaps destructive-- drain on the nation's economy. Secondly, even with a complete radar network in operation there would still be gaps through which planes could fly undetected due the fact that radar is often ineffective at lower altitudes…. The only practical answer to radar's limitations is to supplement it with a means of detection by human eyes and ears. This is the vitally important task, which has been assigned to the GOC.[25]

Chidlaw was not alone in this position. Admiral Arthur W. Radford, Chairman, Joint Chiefs of Staff, for example, was later quoted as saying: "The GOC is a most necessary part of our Air Defense System and is the only answer to low altitude surveillance until electronic equipment is perfected which can serve this function."[26] These statements—quoted here from promotional material—were more than lip service; During the next decade ADC would work on automating the detection of

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[24] Chidlaw, "The Invaluable Contribution."
[25] Ibid.
[26] *What America's Leaders Say About the Ground Observer Corps* (Washington D.C.: U.S. Government Printing Office / Advertising Council, The Ground Observer Corps, c-16-70453-1, 1952).

enemy airplanes as part of the SAGE project but the reality of 1951 was that deployable radar wasn't yet ready.[27]

The Air Force started recruiting volunteers and conducted experiments in fall of 1949, as part of "Operation Lookout".[28] Successful interception of enemy aircraft depended on several factors that included both the volunteers' capability to perform the task of identifying hostile aircraft as well as the system's ability to communicate this information to filter stations that would launch interceptor aircraft. Based on encouraging initial results, the Air Force's Continental Air Command prepared to activate the GOC on a much wider scale. Phase I of the GOC development plan was completed in February 1950 in 25 states along the coasts and in the Great Lakes area. Phase II was completed in March 1951 and expanded the coverage to 11 more states. By the end of 1951, 49 Filter Centers were in operation in 36 states.[29] Over forty thousand volunteers were on active duty and several thousands more were on call. Soon, however, drills showed that at such staffing levels the operation was ineffective. The reason was that round-the-clock operation was not possible with these levels of personnel; having observation posts partially manned created intolerable delays in surveillance.[30] The key to cutting down the delays was to scale the operation; partially manned stations were useless because the surprise enemy attacks could come at any

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[27] Hughes, *Rescuing Prometheus : The Story of the Mammoth Projects--Sage, Icbm, Arpanet/Internet, and Boston's Central Artery/Tunnel--That Created New Style*, Ch. II. An Airforce Magazine Article from 1956 that reviews the development of the Distant Early Warning (DEW) line system, claims that the development in 1952 of reliable long-range communication through use of VHF ionospheric and UHF tropospheric scatter propagation, together with the development of audible alarms, was starting to change the minds of Air Force officials who for the first time thought that radar-only solutions will be feasible. See Charles Corddry, "How We're Building the World's Biggest Burglar Alarm," *Air Force Magazine*, February 1956.

[28] Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense 1945-1960*, 157-59.

[29] Charles H. Darling, *Letter from Goc Special Project Office to Martin Lerner, Newman and Katz Law Offices with Information on Goc and Civil Defense* (Washington D.C.: FCDA central files, February 18th, 1958).

[30] Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense 1945-1960*, 157.

hour. For successful interception of enemy aircraft large numbers of observers were needed so that an efficient 24-hour coverage blanket could be established.

An immediate question arose regarding how to convince more citizens to participate without conveying the message that the Air Force was weak and could not defend them properly. To get participation to the level necessary, a national campaign was called for, involving federal guidance and collaboration with the Federal Civil Defense Administration (FCDA). Expectedly, Air Force generals' and Civil Defense administrators had very different interpretations of the system they were trying to build together. The generals approached the problem from their militarized perspective that viewed air defense as a technical problem. From that point of view human observers were perceived as a cheap way to augment a technology that was not yet ready; as soon as the technology would be available, they should be replaced. In contrast, the civil defense administrators understood the GOC as part of long tradition of civil defense for which the citizens ability to help themselves and not be dependant on military forces in the event of a surprise strike, was a pillar. From that perspective, the participation of civilians in defense work was the rule, not the exception. The only common ground was that there was an acute need to incorporate civilian volunteers into military observation work, and this provided sufficient grounding to start one of the largest volunteer recruiting efforts in U.S. history.

Operation Skywatch begins

For the Truman administration, the establishment of the GOC created a stone that could kill two birds-- it solved a military problem in a relatively affordable way and it gave concerned citizens a palpable way to participate in an invisible war. On July 12, 1952, in the middle of the Korean war, President Truman issued a revealing statement announcing the inauguration of the GOC:

> Starting Monday morning, in 27 States, civilian volunteers of the Ground Observer Corps will inaugurate "Operation Skywatch." This is a commonsense precaution in which Americans can serve proudly and in which the fellow citizens of the watchers can derive satisfaction. The total policy and efforts of the United States and its allies are to prevent war. We shall never diminish our hopes and labors in this cause as long as no aggressors attack us. However, in this new age in which hostile forces are known to possess long-range bombers and atomic weapons, we cannot risk being caught unprepared to defend ourselves. We must have a trained force of skywatchers. If an enemy should try to attack us, we will need every minute and every second of warning that our skywatchers can give us. In that awful eventuality, the margin of warning may make a critical difference in the effectiveness of our air and ground defenses, and in the efficacy of our civil defense measures--it could save many lives and facilitate protection of vital services and production. Our greatest hopes for peace lie in being so strong and so well prepared that our enemies will not dare attack. Every citizen who cooperates in "Operation Skywatch" as well as in other defense activities, is helping prevent the war none of us wants to happen.[31]

Truman calls this move a commonsense precaution, but in retrospect it can be seen as part of the vicious cycle of containment that soon turned into a global prisoner's dilemma. This was a first step towards a strategy that later became known as Mutually Assured Destruction (MAD), according to which Washington and Moscow divided up the globe through a balance of nuclear terror that depended on each country's ability to retaliate in case its adversary launched a nuclear strike first. The theoretical key for MAD's success was the capability to strike back before the enemy disrupts retaliation capability, and this is where skywatchers came in. Clearly the President accepted the Air Force's interpretation that accepted the GOC as an essential part of the air defense system. However, in doing so, he had a second motivation. Fears from a surprise Soviet air-strike were fueled, in part, by the military's own realization that the state of air-defense was deficient. In particular, the Northwest was seen as a likely bombing

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[31] Harry S. Truman, "Statement by the President on the Ground Observer Corps' "Operation Skywatch"," in *Public Papers of the Presidents of the United States* (Washington, D.C.: United States Government Printing Office, 1952).

target due to its geographic proximity to the Soviet border and it being the home of key defense industries, like Boeing, and several large military bases. When the Army Air Force announced plans to relocate its bomber production to the more defensible Boeing plant and headquarters in Kansas, the plan was thwarted by local opposition campaigns that called the government to “Keep Boeing -- Defend Seattle.”[32] Truman thus got a showing of the people’s power. He needed a way to avert this pressure and calm the population down. To coordinate this effort he established the Federal Civil Defense Administration (FCDA) in January 1951.[33] The FCDA’s role was to mediate between the civilian sector and the armed forces while preparing the nation for the new nuclear reality. Much of the workings of the GOC was determined in the negotiations that occurred between the Air Force’s ADC and the FCDA. As I explain below, this process was not smooth at all.

The Time For Air Defense is Now

The creation of the FCDA brought into question the degree to which civil society should be militarized to defend itself against internal and external threats. It dissolved further the already-blurry lines between the responsibilities of the state and its citizens as these pertained to funding and implementation of a home-front security program. The FCDA exemplified a mindset that perceived “self-help” as an American value and held that, in the case of a real emergency, citizens should be autonomous rather than rely on the government for protection.[34] Accordingly, the FCDA focused on educating the public in preparing atomic shelters, formalizing evacuation plans and recruiting volunteers for paramilitary organizations such as the GOC.

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[32] Sharon Boswell and Lorraine McConaghy, "The Atomic Era Dawns," *The Seattle Times*, July 21st, 1996.
[33] See *Federal Civil Defense Act of 1950*, 81-920, (January 12 1951).
[34] McEnaaey, *Civil Defense Begins at Home: Militarization Meets Everyday Life in the Fifties*, 11.

Soon after its inception the FCDA started developing campaigns aimed at mobilizing the general public into civil defense efforts, focusing on cities likely to be targeted by the Soviet Union in the event of a nuclear war. In 1951, for example, in collaboration with the U.S. Army and Ad Council, FCDA organized 'Alert America', a traveling educational show that demonstrated both positive and negative aspects of nuclear power.[35] During 1952 'Alert America', which was advertised as "The show that could save your life", was seen nationwide by over a million people in eighty-two cities. By organizing shows like this the FCDA hoped to, on the one hand, awaken in the viewers a strong sense of patriotism and personal responsibility while, on the other hand, calming fears regarding a nuclear attack. The show was also used as a recruitment tool appealing to the visitors' sense of patriotism in asking them to make commitments to volunteer for their local civil defense agencies.[36]

In contrast to training people in evacuation or shelter preparation, recruiting volunteers for 24-hour skywatching proved to be a major challenge for civil defense authorities, and would remain so for the GOC's entire operation. Volunteers willing to spend the time, effort, and money (for travel, equipment, food and heating) that were required for training and manning the observation posts, were hard to come by. FCDA administrators believed that the recruitment challenge was partly due to the public's dismissal of the risks associated with a nuclear attack, which was triggered by irresponsible statements by Air Force officials who understated the Soviets' capabilities while overstating the capacity of automated air defense to cope with the

[35] Joshua Binus, *Alert America Civil Defense Show June 22, 1952* [Web] (Oregon Historical Society, 2004 [cited 06/07 2006]); available from http://www.ohs.org/education/oregonhistory/historical_records/dspDocument.cfm?doc_ID=CBF3C68A-B7E7-1EB2-EF41FDDF918D6CF6.
[36] Ibid.

threat.[37] On June 16, 1952, Milard Caldwell, civil defense administrator, and other civil defense directors met with the heads of the Air Force at the Pentagon trying to resolve the conflict. Caldwell thought that the Air Force was not honest with the American people because they believed that the Air Force could protect them regardless of civil support, when in fact it could not. Caldwell wanted the Air Force to acknowledge the air defense threat and emphasize the importance of civil defense. In his remarks at the meeting he stated that:

> From 1945 and henceforth wars are going to be won or lost by the people on Main Street…most people on Main Street now believe that the Air Force can keep the enemy attacking planes from getting through, or at least a very high percentage of them. That isn't a fact. The people on Main Street do not believe that their services are needed, and I must confess I am not critical of them at all…I don't see how you can ever hope to get the public to give of their time 24 hours a day or one hour a day, in Ground Observer Corps work, or any other work, until we get all of these questions resolved and get all of the people to understand what the problem and threat are.[38]

Caldwell demanded that the Air Force either acknowledge the threat and issue clear statements about it or withdraw the demand for 24-hour skywatch duties. Having to choose between admitting its vulnerabilities and relinquishing a scaling up of the GOC, the Air Force chose the former. Nathan Twining, the Air Force's acting Chief of Staff stated that the GOC complemented the radar system in important ways. As such, the GOC was an essential element to air defense that must work in harmony with he other elements. Twining concluded that:

> Twenty-four hour surveillance throughout the vulnerable parts of the United States, to detect the possible approach of enemy planes, is essential to the completeness of our defense…I know that twenty-four

[37] Milard Caldwell, *Remarks before the Meeting of Civil Defense Administrators* (Washington D.C.: U.S. Government Printing Office, Joint Public Education Program on Air Defense, GPO 84-35965, June 16th, 1952).
[38] Ibid.

> hour operation of the Ground Observer Corps to furnish low-altitude surveillance imposes a hardship on the members of the Corps and the Civil Defense System. But the entire military side of the air defense system has been on the 24-hour alert for several years. The necessity of the sacrifice cannot be disputed.[39]

Air Force officials realized that the only way to enlist more volunteers to assist the 200,000+ skywatchers who were already on duty was to admit the threats and to cooperate with local civil defense authorities. On August 7, 1952, the Secretary of the Air Force, Finletter, and the FCDA Administrator, Caldwell, released a joint statement that stated basic 'facts' about the threat of a Soviet attack and conceded that "the existing and prospective military resources available or likely to be available for our air defense are insufficient by themselves for adequate air defense."[40] This was a big victory for the FCDA approach, paving the way to cooperation with the Air Force and the launch of a joint campaign that aimed to enroll 300,000 more civilian skywatchers intended to man more than 19,000 observation posts in total.[41]

The key objective of the campaign was to convince the public—once and for all—that the danger was clear and present. An organization called The Ad Council was put in charge of preparing promotional material for distribution and it soon released a series of pamphlets, posters, and window cards. In addition Ad council engaged potential volunteers with a television movie titled *One Plane, One Bomb, One City*, narrated by the famous anchor Edward R. Murrow,[42] and also started a radio

[39] Nathan F. Twining, *Remarks before the Meeting of Civil Defense Administrators* (Washington D.C.: U.S. Government Printing Office, Joint Public Education Program on Air Defense, GPO 83-35967, June 16th, 1952).
[40] *The Time for Air Defense Is Now* (Washington D.C.: U.S. Government Printing Office, Joint Public Education Program on Air Defense, GPO 83-38693, August 7th, 1952).
[41] Ibid.
[42] "Drive for Volunteers Gains New Support," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 5 (1953).

program that was to be aired on Saturday nights on 1,500 local stations, featuring famous disk jockeys.[43]

Simply put, the campaign's strategy was to scare the public into cooperation. One radio ad, for example, announced: "The Reds right now have about a thousand bombers that are quite capable of destroying at least 89 American cities in one raid…won't you help protect our country, your town, your children? Call your local Civil Defense Office and join the Ground Observer Corps today."[44] Like the radio ads, through imagery and historical references, the printed and visual promotional material portrayed the GOC effort as a matter of life and death. The pamphlets and posters used slogans like "Wake Up! Sign Up! Look Up!" and "One if by land…Two if by sea…YOU if by air!"[45] One poster, for example, titled "*Call it Insurance…LIFE INSURANCE'*"[46] claimed that the 'Reds' are in striking distance of 89 American cities, threatening 11 million Americans. "Will you give 2 hours a week to help keep your family alive?" the poster asked. Other posters portrayed images of abandoned children, sitting in what looks like devastated war zones, while the subtitles shout "Don't let this happen to your family." Other posters displayed young women watching the skies of their small-towns in middle-America while the title reads "Don't let [city name] become a second Pearl Harbor" (Figure 5-1). The women in the posters are distinctly white, middle-class, and portray a sort of American ideal, conveying the message that this mission was every woman's business.

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43 "Airwaves Carry Goc Story," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 3 (1952).

44 Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense 1945-1960*, 159.

45 This slogan is a reference to the term "one if by land, two if by sea" that referred to a simple warning scheme that was used in Boston during the American Revolution and was based on lighting lanterns at North Church's window. The terms was immortalized in Henry Wadsworth Longfellow's poem *Paul Revere's Ride* which reads: "One if by land, two if by sea; And I on the opposite shore will be." Such allusions made a direct connection between the current threat and that of the war of independence.

46 *Call It Insurance...Life Insurance* (Washington D.C.: U.S. Government Printing Office / Advertising Council, The Ground Observer Corps Recruitment Poster, Ad 41 GOC, 1952).

Figure 5-1: GOC Recruitment Poster 1952.[47]

[47] Source: *Don't Let Smithfield Become a Second Pearl Harbor* (Washington D.C.: U.S. Government Printing Office / Advertising Council, The Ground Observer Corps Recruitment Poster, GOC 19B, 1952).

Air Force statistics show that in the six months following the scare campaign GOC membership more than doubled. By February 1953, there were 203,648 skywatchers enlisted and 47,475 volunteers on stand-by, ready to man observation posts if called.[48] Figure 5-2 shows the deployment of ground observers in 1952. All the coastal and border states were on high-alert and were dubbed “Skywatch” areas whereas more inland states were on stand-by, meaning that observation towers were not manned 24 hours daily. 49 Air Defense Filter Centers were scattered around the country, ready to accept aircraft flashes.

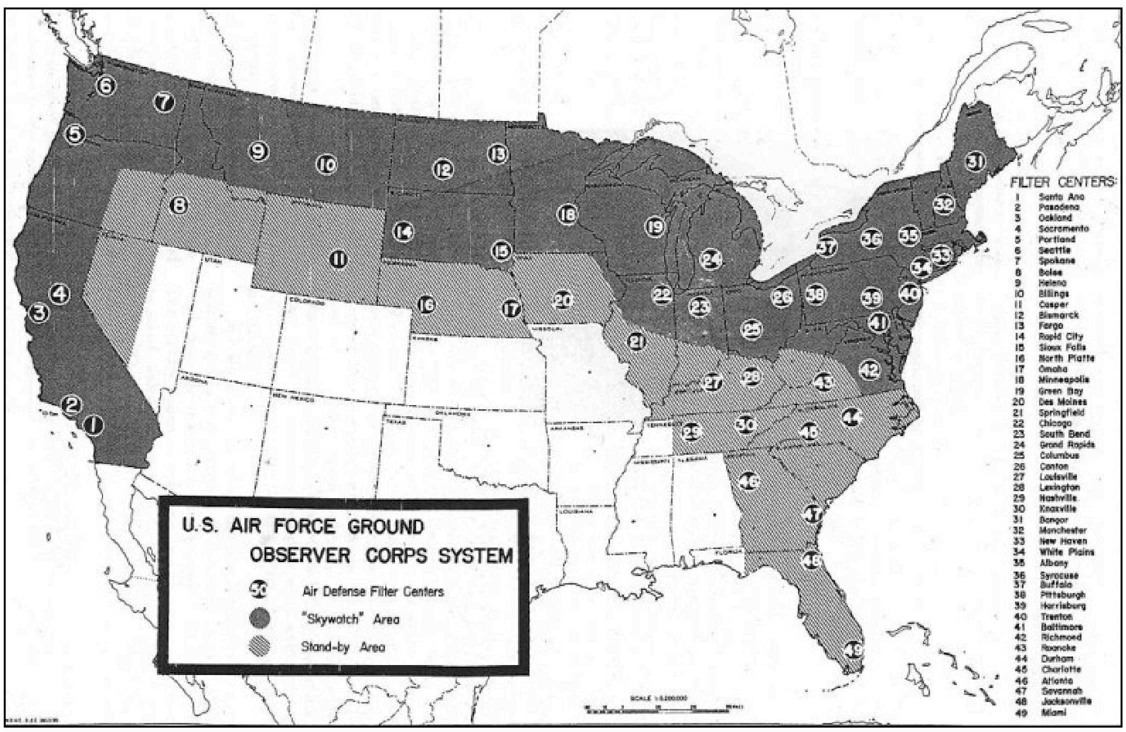


Figure 5-2: GOC Deployment (circa October 1952)[49]

[48] "Tabular Index to Ground Observer Corps Manning Status," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 5 (1953).
[49] Source: Smith-Brooks, "U.S. Air Force Ground Observer Corps System Map," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 1 (1952).

Notably, detailed statistics and detailed maps on the troops deployment were publicly available in the GOC magazine. As much as the scare tactics were aimed at Americans, the publication of GOC readiness status was aimed at the Soviets. In a fully closed system the number of troops can be considered a top secret, but, as is clear from Truman's statement, devising victorious nuclear strategies was a psychological game as much as it was a technological one. By giving out details on its readiness the U.S. was signaling to the Soviets that the likelihood for success of a surprise attack on American cities was low. The high likelihood of a retaliatory strike was supposed to be a deterrent against Soviet aggression. But this was a tricky strategy: by summer 1953, the recruitment plan was still tens of thousands of volunteers short of its objective of 300,000 observers. The publicly available statistics were becoming a double-edged sword. Thus, the FCDA together with the Air Force and the advertising council went into the next phase of the recruitment effort. They launched an all-out campaign titled "The time for Air Defense is now" which had three purposes:

1. To create an atmosphere of public awareness on the need for Air Defense.
2. To motivate civilians to volunteer their services as Ground Observers for Observation Posts and Filter Centers.
3. To maintain morale and continuation of the Corps and personnel strength.[50]

The main objective was the same as that of the preceding summer: "to have 19,400 observation posts and 49 Filter Centers manned at the earliest possible date."[51] The campaign utilized all possible media channels, including magazine advertising, newspaper advertising, radio advertising for local radio stations, television clips sent

[50] "Ground Observer Corps Public Education Campaign Guide," (Washington DC: Federal Civil Defense Administration, 1953).
[51] Ibid.

to both networks and local channels, 300 copies of a ten minute 16mm motion picture, car cards distributed to transit companies, a special campaign for corporate magazines, and printed material that included information kits, pamphlets, and brochures. In addition the FCDA coordinated with the Air Force's Public Information Office in New York the preparation of a national public relations campaign that hoped to attract coverage in the media and tell the GOC story. In addition a merchandising and promotion campaign was prepared for Sears, Roebuck and Company for which a special promotion kit and window display materials were developed.[52]

Once the Air Force acknowledged its inability to defend the population, the FCDA focused on what it did best—mobilizing the citizens to help themselves in civil defense. Using its joint campaign with the Air Force, the FCDA was trying to establish the GOC as a primary option for citizens who believed in self-help and wanted to prepare for a potential invasion. The audiences for this campaign included potential recruits as well as those who already joined. In the next section I investigate how the GOC worked in practice, and how hundreds of thousands of volunteers were brought together.

The GOC in action

This section explores fundamental aspects of the GOC's work. The GOC was clearly a complex system that depended on the coordination of hundreds of thousands of people. Clearly, volunteer ground observers had a vital role, but what did it mean to become a volunteer in the GOC? Who chose to do it and why? How was the work of so many lay people distributed and coordinated? How was the information flow

[52] Ibid.

managed? How did the GOC solve problems of large-scale participation, coordination, cooperation and motivation, and why was it so hard to get volunteers?

I start by exploring the topology of the GOC network. GOC volunteers assumed one of two roles: they were either trained to man observation posts, detecting and identifying aircraft and transmitting "aircraft flash messages", or they were positioned in Filter Centers, which were located at nearby Air Force bases and collected sighting and detection reports. Ground observers manning the stations would report over a radio connection the aircraft's type, function, altitude, heading and direction, the time delay in reporting, and any special remarks. Volunteers in the filter center would aggregate such data and decide if there was cause to launch interceptor aircraft.

Figure 5-3 shows the flow of air defense information. At the heart of the system was the Air Defense Direction Center (ADDC). ADDCs were coordinating bodies, which received ground observers reports through regional filter centers as well as from early warning radars. Messages transmitted from ground observers to filter centers and from filter centers to ADDCs would sound something like this: "Coca Foxtrot three one four two… 0934… northwest… two two nine Tango… two… multi… low."[53] What this meant was "Here is some ground observer information on a flight of aircraft not previously reported. The last known location of the flight was at coordinates Coca Foxtrot three one four two. This last sighting was at 9:34 a.m., local time, with the planes flying northwest. The track number assigned to the flight is two two nine tango. The flight consists of two multi motored aircraft flying low."[54] In the case of a suspected attack, ADDCs would alert interceptor aircrafts, army antiaircraft

[53] "What Happens to Ground Observer Information When It Leaves the Filter Center?," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 6 (1953).
[54] Ibid.

artillery units, and the Air Defense Control Center (ADCC). ADCC would in turn warn Civil Defense authorities which would warn the general population and send them to air-raid shelters.

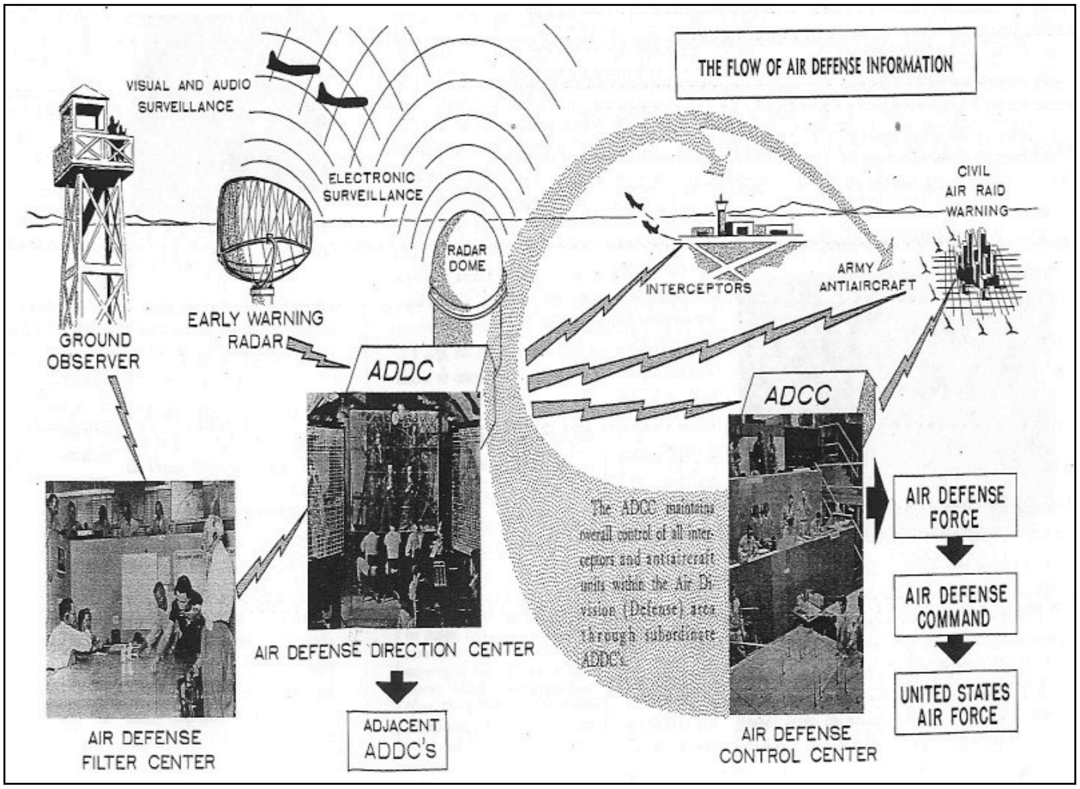
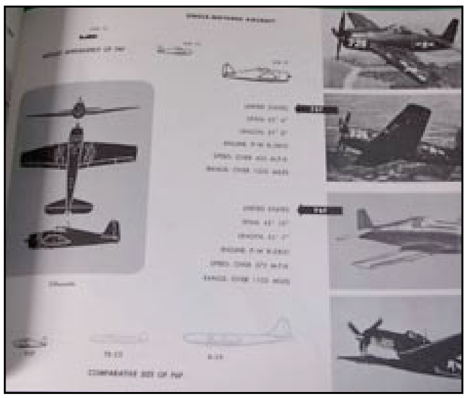


Figure 5-3: The flow of air defense information, 1953[55]

Published by the Air Force in 1951, The *Ground Observers' Guide* was both a technical manual and a means for propaganda. It provided observers with the technical

[55] Source: "The Flow of Air Defense Information," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 6 (1953).

tools necessary for their observation task mixed in with motivational information.[56] The manual provided technical instructions on how to identify and report enemy aircraft but also explained to new recruits that "to stand constant guard at the cracks in our armor we must have alert, conscientious and capable lookouts. That is where you come in."[57] (See page inserts in Figure 5-4)



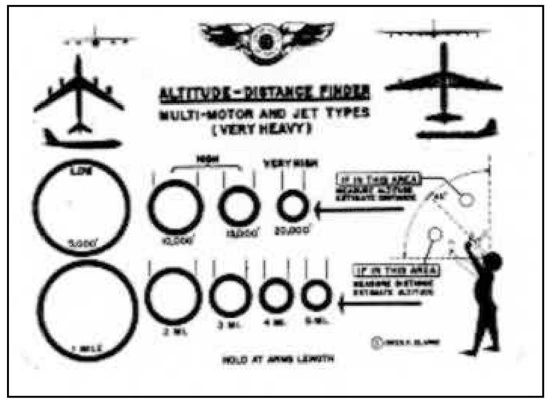


Figure 5-4: Pages from the Ground Observer's Guide (1951)[58]

Who were the volunteers who donated their time, effort and money year-round and round-the-clock? For the most part they were average citizens who were convinced by the civil defense doctrine and abided by the principles of individual self-protection. Volunteers came from all walks of life and all regions in the country, and included men, women and children.[59] It was not uncommon for husband-wife or

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[56] *Ground Observers' Guide, Af Manual 50-12*, *United States, Department of the Air Force* (St. Louis, MO: Universal Printing Company, 1951).
[57] Quoted in Andy Smetanka, "Gimme Shelter," *Missoula Independent*, July 22 2004.
[58] Image Sources: Left: Aviation-Antiques, *Ground Observers' Guide* [Web] (2006 [cited 05/18 2006]); available from http://www.aviation-antiques.com/1947-military-2.html. Right: *Ground Observer Corps Exhibition* [Web] (The Air Defense Radar Veterans' Association Online Air Defense Radar Museum Collection, 2006 [cited 06/07 2006]); available from http://www.radomes.org/museum/documents/GOC/GOC.html.
[59] Miss Strong, for example, was 12 years old when she manned the Observation Post in Scotts Valley, CA, for the first time. Over the years she logged in over 2000 hours. Her parents logged in over 8000 hours each. See Eric Taylor, "Scotts Valley's Past: Skywatch Scotts Valley's Original Homeland Security," *Scotts Valley Times*, February 2002.

mother-son teams to go on duty together.[60] Several observation posts were built on the premises of Army and Air Force bases, depending on the work of military families and off duty military personnel, but the majority of volunteers were regular civilians who held other jobs and skywatched on top of any other duties they had.

As made clear by the promotional material, the recruitment effort aimed to attract women as well as men and exemplified the important role that women played in this game, essentially granting women equal power and rights.[61] Many women, in some cases more than men, accepted the challenge. (Figure 5-5)

As I explained in the previous section, throughout the operation there was a constant shortage of volunteers. This situation called for a reduction in the barriers to participation. The GOC recruited anyone who could get the job done, including blind people, who reportedly used their acute sense of hearing to compensate for their loss of sight, sometimes outperforming fully-sighted observers.[62] In other instances the GOC accepted handicapped persons, including crippled children, hoping that participation in the GOC would open the door for handicapped persons for other types of civil defense activities.[63] In some states like Illinois the GOC established relationship with the Boy Scouts to man both observation posts and filter stations.[64] In other instances the GOC made extra effort to accept volunteers who were foreign

[60] In White Planes, NY, for example more than 25 husband and wife teams have enrolled at the White Planes filter center. See"Flashes - What's Going on at Air Defense Filter Centers, Observation Posts," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 5 (1953).
[61] Andrew Grossman discusses the role of women in civil defense and argues that they were largely conceived of as a resource. He finds that gendering, where it existed, was due to a lasting institutional bias. See Andrew D. Grossman, *Neither Dead nor Red: Civilian Defense and American Political Development During the Early Cold War* (New York, NY: Routeledge, 2001).
[62] "Sees by Ear," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 2 (1952).
[63] John A. DeChant, *Director of Civil Defense's Public Affairs Letter to Mr. William P. Mccahlil, the President's Committee on Employment of the Psyically Handicapped.* (Washington D.C.: on file with FCDA GOC manpower files, August 6th, 1954), Letter.
[64] George C. Sullivan, "Boyscouts Plan of Participation in the Goc," (Chicago, IL: American Legion / Department of Illinois, 1953).

nationals, not customarily accepted for defense work.[65] By reducing the barriers of participation the GOC was able to benefit from the work of persons who would otherwise be excluded from defense work.

Figure 5-5: Women as ground observers[66]

Why was it so hard to get volunteers? A key reason was that the scare tactics spoke only to a small part of the population; despite the FCDA's ongoing campaign many people expressed a healthy skepticism concerning the necessity of the entire operation. To many citizens there seemed to be a contradiction between the alleged importance of the task and the way the government managed it; if the GOC was as necessary as the campaign suggested, some people reasoned, why wasn't participation required by law? Mr. Scott Walker, a real-estate agent from West Cornwall,

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[65] S. A. E. Hogan-Shaidali, *Letter to Val Paterson, Fcda Concerning Enlisting to the Goc* (New Haven, CT: On file, FCDA central files, July 23rd, 1953).
[66] Women observers in Scotts Valley, CA circa 1952 (left) and a volunteer on duty in one of the Filter Centers circa 1956 (right). Image sources: Left: Taylor, "Scotts Valley's Past: Skywatch Scotts Valley's Original Homeland Security." Right: *Ground Observer Corps Exhibition* ([cited 12/04/08]).

Connecticut, for example, wrote a letter to his congressman James Paterson, in September 1954, where he expressed a common view. His letter reads:

> In this town [the GOC] requires from 10-20% of our entire population two hours per week to keep the post open continuously day and night. And there seems every prospect for this to continue indefinitely for the foreseeable future. The main point, however, is not the amount of time required, but whether there is a real necessity for it at all. The few Air Force personnel who show up here occasionally of course say that it is. But they are quite unconvincing…The result is an immense amount of hard feeling, heart-burning, and a large proportion of failure to keep the posts open…This thing is either a necessity to the country's safety, or it is not. And if the latter, it is a ridiculous and intolerable burden on the people, and we should be informed to that effect…But if it is a necessity, it should be well and completely done, at all posts, not just a few. It could be done either by the Army (at terrific cost), paid civilians (at great cost), or by civilian volunteers. The last mentioned, as presumed at present, could be efficient and done at small cost to the government. But if this method is to be used the people should be convinced that it is necessary and it should be urged by directive straight from the Government.[67]

To this skepticism the FCDA had no good response other than to restate its view that (a) recent defense exercises have indicated conclusively that the GOC is both necessary and highly effective; and (b) the recruitment campaign was working, shown by the constant increase in the number of volunteers, which at that time reached 370,000.[68] This debate offers an interesting example of how the law, markets, norms and technology interoperate. Given that there was no technical solution to the problem of low-flying aircraft detection, the problem had to be solved using one of the other three forms of regulation. As Mr. Walker understood, and the Air Force clearly agreed, a market-based, price-based solution was out of the question. Understood in these terms, Mr. Walker's question could be rephrased to ask if attempts to reshape

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[67] Scott A. Walker, *Letter to Congressman Patterson* (West Cornwall, CT: on file at FCDA central files, September 16th, 1954), Letter.

[68] Val Petterson, *Director of Civil Defense's Reply to Congressman James Patterson* (Washington D.C.: on file with FCDA central files, October 6th, 1954), Letter.

norms using scare campaigns were the best tool for recruiting, or whether it would have been wiser to change the law.

Correspondence between volunteers and Air Force and FCDA officials from that period serves as primary material that sheds interesting light on that question and suggests that many volunteers felt that legal intervention was indeed required. Mr. Frederick E. Delaney, for example, was the supervisor of the observation post BM30 Red in Darien, Connecticut. He was alarmed by the slow pace at which observation posts were manned and by the failure of his own attempts to recruit sufficient volunteers for his post. During January 1954, he had shown the previously mentioned *One Plane, One Bomb, One City* movie in the local theater, distributed 10,000 pamphlets, and posted 70 posters all around town for three weeks. The result, after 14 months of work, was only 100 observers enlisted at a town of 14,000. Spending much of his time in the field, Delaney believed that he understood the problem and had better solutions. In May 1954 he wrote an 8-page letter to General Chidlaw, the ADC's commander, and sent a copy to President Eisenhower in which he alerted them to the gravity of the situation.[69] He quoted statistics from *Aircraft Flash* of the month before, which showed that in his region of activity the number of observation posts increased from 83 to 92 in 16 months while the same publication claimed that only 1,083 stations operated on a 24-hour basis, compared to the 10,396 observation posts that were needed in order to fully comply with Operation Skywatch's objectives. At this rate, Delaney calculated, it would take 30 years to reach the target. Addressing Chidlaw and Eisenhower, Delaney wrote:

> You at the top must be aware that only about 10% of all the posts you say you require are in operation on a 24-hour basis. Yet, if there <u>is</u>

[69] Frederick E. Delaney, *Letter from the Supervisor of Observation Post Bm30 Red to General Benjamin W. Chidlaw, Commander of Adc* (Darien, CT: on file with FCDA GOC manpower files, May 19th, 1954), Letter.

> urgent need to get the other 90% on 24-hour duty, you fail to communicate that urgency to the public. They, as a whole, are scornful of the GOC; they call us "bird watchers" and other things not nearly as flattering. Remember, too, that of the posts on 24-hour duty, 307 (about 30%) are in military installations, and many of the other 24-hour posts are in life-boat stations, customs posts, fire towers, prisons and reformatories, where personnel are always available. Subtract these from your 1081 posts now on 24-hour duty and you have a very few supported by the general public. It becomes obvious, then, that only a too-small segment of the general civilian population has the least interest in, or belief in, the GOC…perhaps the most important reason for the lack of public participation is that the public…has not been convinced of the NEED FOR THE IMPORTANCE of the GOC….those who carry weight, do not tell them…I think it is because of a wrong attitude on part of those at the top.[70] [Emphasis in the original]

Delaney believed he had ready solutions. First, he surmised, the links to Civil Defense should be severed. He reasoned that CD officials were mainly interested in preparedness programs inside the towns they administered and GOC recruitment was just a source of expense. Second, he proposed, supervisors must be paid because --properly done-- a supervisor's job was almost a full time task. He reached this conclusion from his own experience: "…being a supervisor costs money. I have traveled over 3500 miles to and from the post and on post business. As an individual who must work for a living, spending spare time at GOS activities, I neglect my house, I do no reading, I watch TV but seldom, I rarely find time to visit anyone, and my phone is always ringing."[71] Third, Delaney suggested that the Air Force was not paying enough attention to the posts. Whereas volunteers should have been guided by and interacted closely with full-time Air Force officers who resided in nearby Air Force bases, this rarely happened.[72] Delaney writes, "When a person gets into the

[70] Ibid.
[71] Ibid.
[72] Filter Stations were based in air force bases that were scattered around the country. Air Force officers would go on field missions, visiting the sites. See *1954 Yearbook for the 28th Air Division (Defense),*, (Hamilton AFB: U.S. Army Air-Force, 1954).

GOC, who trains him? I do. Does the new observer ever see an airman? Only if he happens to be on duty during the sometimes-once-a-month visit paid to the post."[73] All these faults could be corrected, Delaney surmised if the Air Force took the GOC fully under its wings as a full military organization.

Delaney was not alone in the view that control over the GOC should be centralized and that it should be handled with a top down approach. Other GOC members proposed variations on the same theme. Mr. and Mrs. Stuart MacKenzie, for example, acted as the supervisor and chief observer of GOC post Nectar Hotel 32 Black in Chester, Virginia. In late 1952 they permitted an observation post to be built on their property. For the first five months it operated from their house until, with the aid of a few neighbors who donated construction material and labor, they were able to construct an observation tower a few hundred feet from their home. Their hope was that proximity might contribute to keeping the post in operation and allow them to supervise it closely. A year later, in September 1953, they were still facing problems of staffing, and wrote a letter to President Eisenhower, sharing with him the realities of GOC recruitment. When approaching potential volunteers they would often get the same response, they reported: "if it is so important, why doesn't the government do something active about it and not leave it all to you and a few of the airmen at the filter center?"[74] In their letter they pose the same question to the President: if the GOC work was so essential why does the government not draft observers for 2 hours a week as mandatory service? In response they received a standard reply that commended them for their effort. A year passed, and the situation only deteriorated. In a letter from

[73] Ibid.
[74] Stuart MacKenzie, *How Can Operation Skywatch Be Made 100% Active? (Letter to President Eisenhower)* (Chester, VA, September 8th, 1953), Letter.

October 1954, the MacKenzies addressed Val Peterson, FCDA administrator, and alerted him that their observation post was still operational, but at a great cost:

> Many former observers have given up serving at the post as a result of seeming lack of interest in Washington….due to lack of sufficient volunteers we have been unable to leave our place for more than a few hours at a time during the two years! … We are now beginning to feel that we are just a little bunch of gullible idiots who are deluding themselves by thinking that they are grand and loyal citizens because they give unselfishly of time, efforts and money to keep Air Watch posts going.[75]

In their plight, the MacKenzies conceived of a solution: grant FCDA authority to recruit observers by decree. They understood that this would be expensive and would require tax increases, but believed it would serve justice better. They wrote:

> We pay taxes to maintain a military organization…what is its good if it has no authority to build up a proper civil defense system? Or is this just all a political football? … It is a bitterly unjust and a most unstatemanlike system that would condone a situation wherein a few should work so conscientiously and dependably without pay in order that the many should be relieved of greater taxes for the protection of their Country.[76]

At the end of this long letter, the MacKenzies offered their resignation, to be reconsidered only if the FCDA was able to supply them with "reliable dependable, adult observers." The FCDA's response stated that conscription was not the solution, and that the chosen solution of voluntary participation would remain intact.

Other volunteers felt that the solution might come in the form of a market solution after all. A letter from the same summer comes from Mr. Lee of Luverne, North Dakota, and his wife, who wrote to their senator Willaim Langer, to suggest a

[75] Stuart MacKenzie, *Re: How Can Operation Skywatch Be Made 100% Active? (Letter to Val Peterson)* (Chester, VA, October 4th, 1954), Letter.
[76] Ibid.

new motivational scheme for the GOC that would be based on distribution of small sums of money. They write:

> The wings are swell but lots of people think they're some emblem from a son who is in the Air Force, until its been explained. I've shown many people how our Post operates and they say you mean we do all this and don't get anything for it, and I say yes and I'm proud to do it. They say well I think you're crazy to do all that work for nothing…there are lots of old people who could and would love to do the work if they could earn a little extra money.[77]

Lee's, Delaney's, and the MacKenzies' letters suggest a bleak picture: at least in their respective communities Operation Skywatch never met its own objectives. Their suggestions for improvement, however, fell on deaf ears. Despite theirs and many other suggestions by civilians to change the organizational structure of the GOC, such a change never occurred. As I explain below, this was because the GOC would soon be transitioned to a lower alert level and also because in other parts of the country recruitment efforts had much higher success rates. In fact, in some communities the percentage of volunteers was astonishing. In Grantsburg, Wisconsin, for example, 479 men and women out of a population of 983 enlisted.[78] What accounted for such radical differences? I want to suggest that one explanation is that community structures were different. In a situation where norms, and not markets, law, or technology, were the primary modes of regulation, the GOC succeeded where the recruitment effort relied on existing social structures and became a community affair that harnessed participants' desire to buttress their identities within their communities. Where fear of the enemy could not get sufficient levels of volunteers, community roles played a determining role.

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[77] Sig Lee, *Letter to Sentaor William Langer Concerning Problems in Recruiting Volunteers for Goc* (Luverne, North Dakota: on file with FCDA central files, July 13, 1953).
[78] "Flashes - What's Going on at Air Defense Filter Centers, Observation Posts."

In some places, participation in the GOC was a community affair, and the observation posts themselves as well as the training centers occupied community buildings that were highly visible to members of the small towns in which the GOC posts were scattered. In Hinsdale, Illinois, for example, the GOC post was positioned atop the community house; code-named Coco-Metro-Zero-Four-Roger, the observation post was little more than an unroofed plywood pen about six feet square, unfurnished except for a telephone. In Otsego County, New York, the volunteers operated from a shack set up in a field near the bus garage. In Scotts Valley, California, Papa-Hotel-Zero-Zero-Black was on a knoll near the local community center. In Akron, Ohio, the observation post looked like a greenhouse on the roof of the YMCA building.[79]

In these communities participation was much more visible than in remote observation posts, and recruitment efforts were more successful.[80] In places where there was no strong community component, recruitment levels suffered. The problem was even bigger in “ready-reserve” areas in which volunteers were required to be “on-call.” In such cases, there was no direct way for volunteers to exhibit the fact that they were volunteering, and recruitment levels remained low.

Recruitment efforts worked best where volunteers had ways to visualize their contribution to the community. In Cleburne, Texas, for example, GOC volunteers were given all-white coverall uniforms and white helmets to wear on duty. Collaboration with the local radio station KXUL and the Cleburne Times and support from local women clubs boosted participation that rose from 9 in May 1956 to 259 (of which 148 teenagers) less than a year later.[81] In other communities attempts to

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[79] Bruce D. Callander, "The Ground Observer Corps," *Air Force Magazine*, February 2006.
[80] William G. Key, "Air Defense of the United States," *Pegasus: Fairchld Engine and Airplane Corporation Magazine* 1952.
[81] "Whie Coverall Uniforms Feature of Cleburne, Texas, Position," *The Aircraft Flash: Official G.O.C. Magazine* 5, no. 9 (1957).

promote brotherhood and sisterhood were strengthened by participation in social events like fishing derbies.[82] In addition, two GOC-related journals, *Sky Tracks* and *The Aircraft Flash,* chronicled operations and gave a stage for positive reinforcements and accreditation.[83] The *Aircraft Flash*, for example, ran monthly columns with stories from observation posts and filter centers in different parts of the country that highlighted special achievements and acknowledged both individuals and observation posts for their work. All these elements combined contributed to volunteers' ability to build their identity in the eyes of their respective communities. This ability was a base that ensured long lasting participation.

Several sub-groups within the GOC community had even further identity building strategies. As I showed, for blind and handicapped persons, the GOC was an entryway into society and a potential avenue into other civil defense work. For the children in the group, participation often amounted to a combination of an adventure with a rite of passage. One Scotts Valley resident, for example, recalls his memories: "Gee, we were in the 7th grade and they would give us the key…while serving our two and four hour shifts we had access to the soda machine and restroom facilities. There we were, twelve and thirteen years old performing as responsible adults, serving our country by spotting and reporting aircraft movement."[84] Yet for others encouraging participation was a commercial opportunity. Local companies often contributed building material, clothing or food, to gain respect in their communities while exposing their products. One company, Spin-A-Test from Hermosa Beach, California,

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[82] Harold Nelson, *Newport, Maine Goc Post* [Photo] (1953 [cited 06/19 2006]); available from http://www.radomes.org/museum/documents/GOC/GOCNewport.html.
[83] The April 1953 April issue of the Aircraft Flash, for example, details new intelligence tasks given to GOC volunteers collaborating with the 4602nd Air Intelligence Service Squadron, and quotes air force commanders singing their praise. See "Intelligence – a New Role for the Ground Observer Corps," *The Aircraft Flash: Official G.O.C. Magazine* 1, no. 7 (1953).
[84] Ibid.

even thought about adapting their memory aid product line especially for GOC use by developing a game that could be used as a training tool.[85]

A primary mechanism that supported these various identity-building activities was recognition of merit in the form of certificates, awards and medals, which were presented by the GOC commanders upon completion of certain numbers of hours at an observation post or Filter Center. (Figure 5-6) Since there were few measurable results in terms of outcomes (since no Soviet planes were ever detected) the recognition focused on the process, the recording of logged hours. These forms of recognition included both individual awards as well as group ones, including a "Guard Our Country" trophy that was awarded semi-annually to a state for outstanding achievement.[86]

Figure 5-6: Merit Medals for ground observers[87]

In sum, for many Skywatchers a key meaning embodied by the GOC was participation in community activity. Skywatching was a way to defend the country

[85] C. D. Alberts, *Spin-a-Test Memory Aid Proposal Letter to Fcda* (Hermosa Beach, CA: Spin-A-Test Comapany (on file with FCDA central Files), August 27th, 1958).
[86] "Ground Observer Corps Public Education Campaign Guide."
[87] Source: *Ground Observer Corps Exhibition* ([cited 12/04/08]).

while serving the hometown community and participating in a community of fellow Skywatchers. As in the other case studies, the sense of thriving community is a vital part sustaining the system. As I discussed in chapter 2, Julian Kilker showed how the online discussion boards that were used in the development of email protocols allowed computer scientists and government administrators to express their interest in social issues pertaining to both their own peer group and society at large. Kilker argues that taking social identity into consideration when observing group boundaries provides important implications for the notion of 'closure'.[88] I want to suggest that the same approach is useful also for understanding the process by which the network grows and solidifies.

A key element in explaining all these cases of large-scale, volunteer-based information networks concerns the ways in which these networks grow. How is it that more hams join the ARRL? Why do people join free and open source projects, and how do they select which project to contribute to? Why do volunteers choose to spend their nights manning a remote observation post? As I explained earlier, for a variety of reasons the GOC came to solve a problem to which a technical or market-based solution was not available. To this extent, the solution had to be sought by altering the norms of existing communities. Identity-building strategies of individuals within these communities were a prime determinant for the success or failure of volunteer recruitment efforts. As the other case studies suggest, in all the systems I investigated there is a strong component of identity building, which allows volunteers to connect to like-minded people and to portray themselves to their peers, and to themselves, in specific ways. Moreover, in all these systems identity building operates vis-à-vis a community of other volunteers. As Kilker points out, mechanisms of self-selected

[88] Ibid., p. 247

social identification—and not only the relationship with the technology at hand—determine how the system develops. To this end, following Kilker I argue that SCOT gains stronger explanatory power when it pays attention to the ways in which participants identity is constructed in relationship to each other and not only to the technology. The GOC allowed kids to become part of adult society, women to participate in defense work, handicapped persons to regain their social acceptance, and remote villagers to protect urbanites; in other words, the GOC allowed different sub-groups to build their identities in relationship to both technology and society.

Increased participation in the GOC was correlated with the reduction in the barriers of entry, a typical feature of many other open systems as well. To achieve mass participation recruitment efforts were extended to social circles that grew beyond the usual suspects. In the GOC, people who traditionally have been excluded from defense work could become contributors. These participants found more than just a technology to which they could contribute: they found a community to identify with as well. But the same principle is true for all participants. Recruitment efforts were successful when they empowered existing social structures and worked from the bottom up. They were not successful when they used scare tactics and were imposed top-down.

Participatory information systems, as the GOC demonstrates, enjoy two benefits: first, they enjoy a massive labor force that is often working for free or for a small fee; second, participants, almost by definition, are highly motivated (otherwise they wouldn't participate.) Clearly the first benefit relies on the second. Participation in these cases becomes a form of empowerment. In the case of the GOC, the anxiety of scared citizens, which might have otherwise been directed at the government, was funneled into a productive avenue. Many years later, the participatory process of Linux insured that people could participate from within instead of expressing their dissatisfaction from without by, for example, writing malicious software viruses, as happened in the case of common attacks on Microsoft's Windows.

The GOC also demonstrates the important role of reputation management and the recording of contribution. As I explained in the case of FOSS, shifts from money economies to reputation economies, from markets to norms, are often followed by the development of formal and semi-formal mechanisms of recognition of devotion and merit.[89]

The End of an Era

From 1952 to 1956 the advancement in radar technology was tremendous. The Air Force operated early warning radars off aircrafts and ships and was constantly expanding ground radar coverage. Two notable projects were coming together: the Mid-Canada radar line and the Distant Early Warning (DEW) Line along the Arctic Circle. The former was scheduled to become operational in the summer of 1957, and the latter's completion was scheduled for later that year. Both projects were supposed to be integrated into the SAGE system that was designed to give the ultimate solution to air defense and was being worked on hurriedly.[90]

With full radar coverage in the offing, a conference of the GOC review council, a joint body of the Air Force and Civil Defense, was called together on August 8, 1956, to establish policies and courses of actions for the future of GOC

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[89] In a much later period we find a similar dynamic in online communities. The difference in a community that has no existing relationship is that in those cases activities within the system are the only mechanisms of expressing identity and are thus fortified. Discuss these issue at length in Shay David and Trevor Pinch, "Six Degrees of Reputation: The Use and Abuse of Online Review and Recommendation Systems," *First Monday* 11, no. 3 (2006).

[90] "Air Defense Radar Network Expands," *The Aircraft Flash: Official G.O.C. Magazine* 5, no. 9 (1957).

operation.[91] The Air Force generals announced that with the new radars in place GOC posts operating in interior states would not be required on 24-hour alert anymore, but that no firm commitments could be made as to placing the entire GOC on inactive duty. In border states the GOC was still very much needed. Consequently, the GOC was to be divided into “skywatch” areas and “standby” areas. With the completion of the electronic surveillance system, the 24-hour alert areas reverted to standby status. ADC was given the task to introduce this confusing plan to the city and state civil defense directors during October 1956. ADC commanders briefed state directors who in turn were supposed to explain the new policy to local and city directors, but in some cases the new policy was slow to trickle down, and some GOC posts had to learn about it from the press, which clearly upset them. Marvin L. Merritt, for example, the CD director of Peoria, Illinois, sent a raging letter to the FCDA in which he wrote:

> Once again in our opinion, a BONER has been pulled. Can you imagine how local Civil Defense people all over the country felt yesterday when they read in the papers about the GOC program being reduced to a stand-by basis? It really takes the wind out of a person…after four hard years of work building up the GOC, the complete program and efforts went down the drain yesterday morning.[92]

As made clear by this and similar letters, there was much confusion in the field regarding what the new situation was. Was the GOC needed or not? If not, when will it stop its operation? In the following months, the Air Force was moving ahead with deploying the automated detection system. On March 14, 1957, in a discussion of the growth and development of air defense at a Chamber of Commerce event, General Joseph H. Atkinson, commander of the ADC, explained the Air Force’s position:

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[91] Owen F. Clarke, "Minutes of Second Meeting Goc Review Council," (Washington D.C.: U.S. Air Force / GOC Review Council, 1956).

[92] Marvin L. Merritt, *Letter to Val Peterson, Fcda Administrator from the Peoria, Illinois Civil Defense Director* (Peoria, IL: On file FCDA Central Files, November 16th, 1956).

"Technology has really pushed ahead and we are adapting our system to the changes…we recognize the sacrifice of time and effort by GOC volunteers and we want to give them some well-deserved relief."[93] That relief came shortly thereafter in the form of an ADC directive, which called all GOC posts to revert from twenty four hour operation duty to Ready-Reserve status beginning January 1st, 1958.[94] Six years after it was announced, operation Skywatch had reached its end. The directive caused further confusion among the people who made the GOC a part of their lives for the better part of a decade. What did it mean to be in Ready-Reserve status? Was the GOC being disestablished? For the hard core of GOC volunteers, this was hard to believe. Dorothy Pillsbury, Supervisor of the GOC's San Francisco, California, post, for example, made arrangements to keep her posts in a state of readiness for training, test alerts, and reports, and for emergency service. Further arrangements included manning the post on thirty minutes notice for continuous duty around the clock as needed. She wrote letters to her volunteers trying to clarify the situation. In one letter she wrote: "the Corps is <u>NOT</u> dissolved – it continues its existence in full vigor with special emphasis on training and readiness to serve…we do not wish to lose the San Francisco members with their high sense of patriotic duty and their fine spirit of self-sacrifice."[95]

It seems as if this level of dedication, and this level of patriotism was the exception to the rule. In a book titled *The Russian are Coming! The Russians are Coming!* Richard Fried argues that many Americans worried about their car payments more than about the Soviet threat. President Truman, for example, worried about the weakened civic fabric and the public's ignorance and apathy; in a 1952 speech he remarked that "We live in a time sadly in need of discipline, particularly self-

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[93] "We Need the Goc," *The Aircraft Flash: Official G.O.C. Magazine* 5, no. 9 (1957).
[94] Dorothy Pillsbury Stetson, *Letter to Members of the Goc from San Francisco's Post Superviser Regarding Goc Status* (San Francisco, CA: on file with FCDA central files, November 25th, 1957).
[95] Ibid.

discipline, that quality of personal responsibility so essential in the individual called to discharge the duties of citizenship in a democracy."[96] Fried describes how the Ad Council and other organizations created "campaigns to sell America to the Americans,"[97] some of which I described above.[98] In the case of Miss Pillsbury's volunteers, it seems as if the message was well taken, but in general, I have discussed, many people remained skeptical and full of apathy.

From January 1958, and for the rest of that year, the GOC operated on Ready-Reserve status. Fearing the loss of the GOC's tremendous volunteer power, Civil Defense started to redirect volunteers to other CD activities such as radiological defense, reception and care, and services involving fire, light rescue and police work. In November 1958 the Air Force decided that after January 31, 1959 there would no longer be a military requirement for the GOC.[99] Ten years of skywatching came to an end.

Conclusion - The GOC as a hybrid system, an open system within the closed world

One way to understand the GOC is as a hybrid open-closed system. On the one hand, the GOC was based on volunteer work, self-help, self-selection of tasks, and grass roots funding, while, on the other hand, it rested on a skeleton of governmental and military forms of control and organization that were managerial, and centrally controlled. In other words, the GOC can be seen as a closed system to the extent that it was carefully controlled, performed tasks that were assigned from the top down,

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[96] Richard M. Fried, *The Russians Are Coming! The Russians Are Coming!: Pageantry and Patriotism in Cold-War America* (New York: Oxford University Press, 1998), 96.
[97] Ibid. 226
[98] For a detailed review of several of these efforts in the context of a psychological war, aimed both domestically and towards the enemy, see Kenneth A. Osgood, "Hearts and Minds: The Unconventional Cold War," *Journal of Cold War Studies* 4, no. 2.
[99] Leo A. Hoegh, *Letter to Governors Concerning Disestablishment of the Goc* (Washington, D.C.: on file with FCDA central files, November 20th, 1958).

involved information flowing from the periphery to the center, and was subjected, in the last instance, to military and governmental control. It was an open system to the degree that it was highly participatory and that it relied on works of volunteers who were self-funded and self-selected, and that its main mode of social organization revolved around existing communities. The conflict between these competing operating principles highlights the tensions between openness and enclosure. As I argued in the introduction, and as I explained in the cases of Linux and the ARRL, openness is always defined vis-à-vis enclosure. An open system is never fully open, and a closed system is never fully closed. The GOC is worth studying if only for the ways in which it mixed operating principles from these different models, and by doing so illuminated both.

Paul Edwards points out that the development of computers as closed-loop systems triggered a 'closing' of society. He reads the GOC as yet another manifestation of that process. He writes:

> The GOC was another buttress for the wall of the container America was building, another support for closed-world discourse. Its function, like so much of the macabre apparatus of nuclear war, was primarily ideological: a genuine defense being impossible, a symbolic one was provided instead.[100]

I want to argue that by treating the GOC only as a symbolic defense Edwards misses many of the meanings that the GOC embodied. My description of the GOC as an open systems operating within the closed-world discourse builds on Edward's argument and augments it. Edwards writes:

> "Closed-world discourse" thus names a language, a worldview, and a set of practice, characterized in a general way by the following features and elements.

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[100] Edwards, *The Closed World : Computers and the Politics of Discourse in Cold War America*, 90.

> * Techniques drawn from engineering and mathematics for modeling aspects of the world as closed systems
>
> * Technologies, especially the computer, that make systems analysis and central control practical on a very large scale.
>
> * Practices of mathematical and computer simulation of systems, such as manufacturing processes and nuclear strategy, in business, government, and the military
>
> * Experiences of grand-scale politics as rule-governed and manipulable, for example by means of the power of nuclear weapons or Keynesian economic intervention...
>
> * A language of systems, gaming, and abstract communication and information the relied on formalisms to the detriment of experiential or situated knowledge. This language involved a number of key metaphors, for example that the war is a game and that command is control.

This case demonstrates how the GOC complemented each of these with additional meanings. Techniques and technologies were indeed drawn from engineering and mathematics for modeling aspects of the world as closed systems, but humans in filter stations took the place that later computers would occupy (Figure 5-5). Humans also communicated via voice communication, and not with automated signals. Without that human element, central control was not practical on a large scale. Likewise, the GOC augmented mathematical simulation practices with simple drills and simplified tasks that required a lot of man-and-woman-power, but little else. Experiences of grand-scale politics were augmented by small community dynamics, which, as I showed, greatly influenced the level of participation and motivation. The language of systems, gaming, and abstract communication often gave way exactly to situated knowledge. Skywatcher were situated in their communities, learning to recognize traffic patterns in their areas (and as I showed, where flight routes were scarce, it was hard to find volunteers). New metaphors were added, including the main one that saw in citizen-cooperation a powerful shield. In that regard, one can ask if the GOC was a success or a failure? In terms of coverage and effectiveness the empirical evidence that I have surveyed, particularly the reports on the amounts of actual vs. planned numbers of volunteers, suggests that the GOC never achieved its own readiness levels and never met the staffing objectives put forward by the ADC at the beginning of operation Skywatch. In terms of its support of national security, however, the GOC can be considered a success for two different reasons: (1) it bolstered deterrence capability at a time when no technological solutions existed, and (2) it gave concerned citizens a channel through which they could contribute to the national effort in an invisible war. As Edwards points out, within discourse the symbolic defense is as important as the physical one.

Looking back 50 years, the totality of the cold war and the extreme measures that it required from the population illuminates many of today's concerns about the global war on terror and the debate about the necessity of such a war. Depending on one's political beliefs, the scare tactics used to recruit GOC volunteers seem questionable at best. Without those national horror campaigns, it is not clear how participatory the GOC could or would have become. However, the story has an important lesson for democratic culture. As I discussed in chapter 2, democratic culture in an information society is a culture in which individuals have a fair opportunity to participate in the forms of meaning-making that constitute them as individuals.[101] Openness to volunteer participation, the common thread of all the case studies in this work, comes hand in hand with the reduction in the barriers of entry. Participation in the GOC was a meaning-making activity that, importantly, was open to many, including some that have traditionally been excluded from defense work. As

[101] Balkin, "Digital Speech and Democratic Culture: A Theory of Freedom of Expression for the Information Society."

we have seen, this included many women in key roles, and a special effort by FCDA to encourage participation of African-Americans. Laura McEnaaey found that:

> …postwar civil defense officials sought the cooperation of African American organizations immediately in 1950 so that the newly created FCDA would be an exemplar of racial democracy...[but despite FCDA efforts to court the black press] coverage of civil defense issues was scant. There was the occasional article the featured civil defense as a 'human interest' story. Ebony, for example, spotlighted the negro American Legion of Erie, Pennsylvania, who stood watch for Soviet bombers around the clock. Ebony celebrated the fact that blacks made up 30 percent of the volunteer corps in Erie and reassured readers that they had experienced no discrimination at the post...but such coverage never approached the desired volume.[102]

By and large overall black participation remained low and by 1955, after several attempts to understand the roots of the problem, the FCDA admitted its failure in recruitment efforts.[103]

The GOC offers contrast to the other case studies that accentuates the continuities and discontinuities between 'open' and 'closed' systems. Overall, the GOC was quite different from the ARRL or FOSS to the degree that it relied on a different set of motivations and on traditional modes of control. It also differs from the other cases in that information on its network didn't flow between nodes, but was centrally collected. It is reminiscent of the other case studies to the degree that it exemplifies an information network that is open to volunteer participation and that, in the absence of financial compensation requires a skeleton of reputation management and identity-building capacity to hold itself together.

When it comes to motivation for participation, unlike the cases of FOSS or the ARRL in which communities of individuals self-organized for fun or for solving a technical challenges, the GOC was centrally organized and participation in it was first

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[102] McEnaaey, *Civil Defense Begins at Home: Militarization Meets Everyday Life in the Fifties*, 137-9.
[103] Ibid., p. 140

and foremost motivated by local patriotism and fear. The GOC, just like the ARRL, demonstrates the role that participation plays in the identity-building of participants. In such networks, I argue, a fundamental element is the opportunity for participation itself. The value of Linux, for example, stems not primarily from its arguable technical superiority or a reduction in the cost of ownership; likewise, the value of the ARRL stems not from its ability to transport messages in record speeds, and the value of the GOC stems not from its ability to detect Soviet bombers. Rather, the value of these systems derives from their inclusive character, which allows individuals to participate and build their identities within a community. As I showed, in these systems the ability to participate is enabled by a reduction in the barriers of entry that requires a renegotiation of traditional modes of control and organization. This, in turn, requires finding a balance among the system's legal, normative, technological, and financial aspects, that are always in tension. Without the ability to pay for the observers' time and effort, like in a price-based market-based system, or the ability to command them, as in an army-like system, the GOC administrators were always struggling to recruit more volunteers and to keep the ones they had on staff. They did so by building a reputation economy that rewarded volunteers for tenacity and effort, highlighting the important role of reputation in the ongoing maintenance of volunteer-based social structures. As I showed in the cases of FOSS and the ARRL, reputation management and the recording of contribution are key features. Clearly in this case, this strategy was augmented by an economy of fear that did not exist in the other cases. For these reasons I outline the GOC as a hybrid system: an open system operating within the closed world.

In the following chapter I will explore how negotiations along these same dimensions takes place in the field of molecular biology while a group of scientists hopes to employ participatory principles in international agriculture.

CHAPTER 6:

BIOLOGICAL OPEN SOURCE – FROM LINES OF CODE TO SEED LINES

> Q: What is the problem that you're trying to solve with biological open source?
> A: The problem is that in the developed world a can of Coke costs two dollars while in the developing world a billion hungry people earn less than a dollar a day. BIOS can help change this situation.
>
> Richard Jefferson over lunch and a Coke™ in Canberra, Australia, July 2006.[104]

Introduction: Agriculture and the information economy

The previous chapters looked at systems that aimed to produce software, radio relays, and plane-spotting reports—three distinct types of knowledge goods that are centered on information and information processing. This chapter explores the working of a distributed, participatory system that is situated in biological wet-labs and aims to produce a different type of information and information goods. This fourth and last case study investigates an organization called the *Center for Application of Molecular Biology to International Agriculture* (CAMBIA) and a system it started called Biological Innovation for an Open Society (henceforth, BIOS), which aims to extend the metaphor and concepts of open source software to applications of the life sciences.[105] Started by Richard Jefferson, a well-known molecular biologist, BIOS aims to deliver a biotechnological toolbox and a legal framework that will, among other things, facilitate the production of improved seeds and plants, catering to people in developing countries and alleviating problems of poverty and hunger. While in terms of its field of operation, end products, and goals there seem to be significant discontinuities between BIOS and the earlier systems I explored, in the last few years

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[104] Jefferson interview.
[105] *About Bios* [Web] (BIOS, 2006 [cited 01/01 2006]); available from http://www.bios.net/daisy/bios/3.

BIOS, which was started in the early 1990s, has been re-positioned as “Biological Open Source”, hoping to monetize on the success of the free and open source software movement. The deliberate situating of the biological open source initiative as the parallel of the free and open source software movement suggests that, in the eyes of the actors involved, the open source paradigm is extensible to this domain. Moreover, a deeper continuity exists; from an analytic perspective, seeds and plants can be seen as part of the global information economy in their capacity as ‘knowledge embedded goods’ or KEGs.[106] KEGs are artifacts, like seeds or medicines, whose value derives not only from their physical, chemical, or technical composition but, rather, from the information and knowledge embedded in them.[107] As this case study will demonstrate, these continuities are important as many of the tensions between openness and enclosure reappear in the domain of biological and agricultural innovation.

As I investigate these continuities and discontinuities, I will seek to understand what the ‘source’ is in biological open source that can justify the use of the open source metaphor, and will explore what it means to release a bacteria or a strand of DNA under an ‘open license’, trying to explain what other changes to the law are required in a sector that, like radio and unlike software, is dominated by patents rather than copyrights. As I explore the work of CAMBIA, BiOS, and several related organizations, I will try to answer these questions and revisit some of the earlier

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[106] Positioning molecular biology as part of an information economy echoes a more fundamental and often-used analogy that equates the genome to the book of life and DNA to language. It is important to distinguish between those two relations. Lily Kay calls attention to the limits of understanding genetics as part of an informational discourse. Informed by a poststructuralist approach, she explains that molecular biologists used ‘information’ as a metaphor for biological specificity, while failing to realize that it is a signifier without a referent, see Lily E. Kay, *Who Wrote the Book of Life? : A History of the Genetic Code*, *Writing Science* (Stanford, CA: Stanford University Press, 2000), 2. My understanding of modern seeds and plants as KEGs does *not* depend on the lower-level analogy of genes and information, and therefore does not suffer from the legitimate critiques Kay discusses.

[107] Benkler calls these information-embedded goods and tools which “are not themselves information, but that are better, more plentiful, or cheaper because of some technological advance embedded in them or associated with their production.” See Benkler, *The Wealth of Networks : How Social Production Transforms Markets and Freedom*, Ch. 9.

questions concerning the ways in which large-scale participatory systems overcome challenges pertaining to collaboration, participation, coordination, and sharing. To this end, the chapter presents an empirical study of BIOS and also continues with the two theoretical themes of this work, contribution to SCOT and understanding the implications of open systems for democratic culture.

At the empirical level, the bulk of the case study explores CAMBIA's history and contemporary work in an attempt to evaluate the alternative tools and innovation models that it offers to the international community of plant breeders and biological researchers. The study is based on my fieldwork at CAMBIA, a set of interviews with several actors from various social groups, and analysis of online and offline textual sources as well as a review of primary literature. To understand the problems that open agricultural innovation aims to solve and the context in which BIOS operates, I start with a historical detour that briefly describes the shifts that created agri-business and the new affordances that brought the agricultural sector into the heart of the global information economy.

Contributing to my enhancement of SCOT by way of understanding how an international network of researchers collaborate and share not only information but also biological materials, this case will be different from the earlier three cases to the degree that it deals with a system whose meaning had not yet stabilized. The biological open source model, like its software and radio parallels discussed in chapters 3 and 4, faces formidable challenges from incumbents who favor closed, proprietary systems. As in the other case studies, many of the battles would be won or lost through control of developer communities, definition of regulatory regimes, and the creation of political and economic alliances. I will focus on articulating the problems that are still being debated, and survey different attitudes towards biological open source as expressed by different groups. Following the actors who interpret the problem of agricultural innovation as an information policy problem, I will also shift settings and follow the actors from the field, through the biotech lab, and into the patent offices, the legislatures' halls, international fora, and the courts.

Lastly, the case explores BIOS's implications for democratic culture. What is to be gained by opening up the field of molecular biology? What is to be lost? BIOS's artifacts, tools, and methods offer an alternative information economy for agriculture, which in my view supports democratic culture to a greater extent than the existing proprietary models of biological innovation. Particularly, BIOS aims, among other things, to promote the production of greater quantity and quality of food, which otherwise does not reach the stomachs of the world's hungry. In my analysis I focus on this capacity in an attempt to demonstrate that systems like BIOS have an immediate implication not only for the technical elite but also for world's poorest.[108] Despite common perceptions to the contrary, as each year goes by, *more* and not *less* people are becoming hungry. Statistics also show that the food insecurity problem is, surprisingly perhaps, not caused by lack of food or insufficient calorie production but, rather, because the hungriest people do not have the financial and technological wherewithal to grow or buy enough food for their needs. By espousing the values, metaphors, and modes of organization of free and open source software, the advocates of BIOS hope to start a revolution that will bring the benefits of modern agricultural biotechnology to the people who need it most by making them active participants in the political economy of food production rather than passive recipients of bread-crumbs off of the West's sumptuous tables. But clearly there are risks involved, particularly in reducing barriers to entry into the field of genetic engineering, which,

[108] Food insecurity is an acute problem; by 2020 there will be approximately two billion more people to feed, more than double the billion people that lack sufficient quantities and qualities of food today. See "The State of Food Insecurity in the World 2005," (Rome, Italy: Food and Agriculture Organization of the United Nations, 2005).

as we know, is already at the heart of a bitter controversy. The work will end with a discussion of these risks and their implications for democratic culture.

A short history of CAMBIA[109]

To a first time visitor, sleepy Canberra, the peaceful Australian capital, seems like an odd choice for the headquarters of an organization that aims to revolutionize agriculture on a global scale. There are neither fields around, nor other apparent signs of international agriculture, but walking down the trails of the botanic gardens that surround his office, Richard Jefferson, CAMBIA's founder can see much beyond the very unassuming two-story building that houses his labs. Jefferson's vision speaks of nothing less than overhauling the entire innovation system of the biological sciences. Through a set of interviews before, during, and after visiting his lab, I learned more about what had brought him to this Don Quixoteian position. In one interview he explains:

> For years, the multinationals and big seed companies have been spreading fear, uncertainty, and doubt, -- 'FUD' -- and they were aided by misguided public policy, and value-less academic scientists that would do anything for money In the last sixteen years, we are trying to change this. Instead of 'FUD', we are trying to create an atmosphere of legal permissivity and empowerment to developing country scientists. We are starting to win this war.[110]

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[109] Unless otherwise noted, the details about Jefferson's and CAMBIA's history are based on a series of observations, interviews, discussions and email correspondence I have conducted with Jefferson and CAMBIA's team during 2005-6. For verification I've also used the following sources: R. A. Jefferson, *Richard A. Jefferson Biography* [Web] (CAMBIA, 2006 [cited 07/03 2006]); available from http://www.bios.net/daisy/bios/478.html.; and Richard Poynder, *Biological Open Source: Interview with Richard Jefferson, Founder and Ceo of Cambia, and Leading Light of the Biological Open Source Movement* [Web] (September 22nd 2006 [cited October 14th 2006]); available from http://poynder.blogspot.com/2006/09/interview-with-richard-jefferson.html.
[110] Jefferson, Interview.

Much of the logic behind BIOS can be explained as Jefferson's attempt to reverse several trends that he had experienced first hand during his career as a staff molecular biologist in several leading labs. His first big contribution to the field, the reporter gene system GUS (ß-glucuronidase), was a genetic engineering tool for controlling gene transfer into organisms. Before GUS, molecular biologists faced big uncertainties regarding the gene transfer's success. Jefferson's solution was an easy-to-detect marker gene, which in the presence of an activating material turns receiving cells blue, giving a simple visual indication to the process's success.[111] In 1985, Jefferson was awarded a National Institute of Health fellowship that allowed him to move to the Plant Breeding Institute (PBI) in Cambridge, England and start adopting the GUS system, which was initially developed to manipulate the nematode C. Elegans,[112] to plants and agriculture. GUS was being rapidly adopted in labs the world over, and Jefferson started distributing the improved GUS to thousands of labs upon their request, on a first-come-first-serve basis. He didn't charge any money for it, nor did he find it necessary to ask receiving labs to sign any Material Transfer Agreement (MTA), the common legal step taken when biological material is transferred from one organization to another. Instead, he published a journal article about the technology[113] and a non-peer-reviewed 20-page manual that described how the technology was to be

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[111] In a simple process GUS could be attached to any gene of interest and thus the detection of the marker gene in the target organism becomes a good indication that the original gene transfer succeeded too. Instead of waiting for the receiving organism to grow and exhibit the trait controlled by a transferred gene (or not exhibit it if the process failed), using GUS the researcher can simply look and tell. Other advantages of GUS, as later described in the journal *Nature*, included the simplicity of handling it, the ease of synthesizing it, and its accuracy in reporting gene transfer. See R. A. Jefferson, "The Gus Reporter Gene System.," *Nature* 342 (1989): 837.

[112] Caenorhabditis elegans is a 1 mm nematode that was made famous by Noble laureate Sydney Brenner that chose it as a model organism for the investigation of animal development including neural development.

[113] R. A. Jefferson, T. A Kavanagh, and M. W. Bevan, "Gus Fusions: ß -Glucuronidase as a Sensitive and Versatile Gene Fusion Marker in Higher Plants," *EMBO* 6 (1987).

used.[114] Within less than two years Jefferson's articles became among the most cited sources in molecular biology, and GUS became a standard technique used in virtually all molecular biology labs around the world. Because it was given out for free, worked brilliantly, and came with a full manual, the new reporter gene system rapidly became widely accepted as a standard tool for gene reporting.

When commercial firms asked Jefferson to license his technology for their commercial operation so that they might use it or build upon it, it occurred to him to file a patent for it, which he was subsequently granted in 1987,[115] and which later proved to be a major source of funding for CAMBIA. Getting the patent was Jefferson's first lesson in the maze of intellectual property law and the tremendous costs associated with a patent strategy. Jefferson's university declined to fund the patent filing because they failed to understand GUS's commercial value, so Jefferson had to pursue the patent himself. He hired a famous patent lawyer and since he couldn't afford the attorney's fees he agreed to share the revenue with him, an arrangement that later was the heart of a legal dispute when it became clear how valuable GUS actually was.

Inspired by his early success Jefferson searched for an academic position that would allow him to start a small research center and develop further technologies that could be applicable to plant improvement. The search was futile since Jefferson was stuck in the rift between plant breeders and molecular biologists, with each discipline enmeshed in its own practices and politics. As Jefferson recalls, "plant molecular biology" was not yet a field; plant breeders were out in the greenhouses and fields and molecular biologists were in the lab. Jefferson was among the few at that time that was

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[114] R. A. Jefferson, "Assaying Chimeric Genes in Plants: The Gus Gene Fusion System," *Plant Molecular Biology Reporter* 5 (1987).
[115] R. A. Jefferson. "Plant Promoter ß-Glucuronidase Gene Construct." US:5268463 Jefferson, Richard A., 1989.

included in the technological frames of both plant breeders **and** molecular biologists. The connection between those two frames in the late 1980s was still loose, but this situation was bound to change as industrial interests soon realized how valuable advancements in molecular biology could become for agricultural innovation.

By the end of 1989, being interested in fieldwork more than in publishing academic papers, Jefferson gave up his academic career and started looking for alternatives. He worked for six month for the United Nation's Food and Agriculture Organization, but he soon realized that the UN, filled with political rivalry, was hardly the place for his grand ambitions. His next job was with the Rockefeller Foundation, working for Gary Toenniessen, the man that since 1985 had been behind Rockefeller's $100 million rice program.[116] As Jefferson recalls using a typical phraseology, Toenniessen assigned him the task of "debugging" rice-research in the developing world. In other cases too I have often heard him use computer metaphors to describe his work.[117] He was expected to hire a technician and fly into labs in South East Asia in order to help developing-country scientists figure out how to promote new rice varieties that Rockefeller scientists had developed.[118] Jefferson needed to be in the same time zone as his clients, and so came the idea to move to Australia, which shared a time zone with many South Asian cities.

Developing the Vision

Having spent time in many of the developing world's agricultural research labs where molecular biology was just being introduced, Jefferson realized that agricultural

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[116] *Profile of Dr. Gary Toenniessen Director, Food Security, Rockefeller Foundation, New York, USA* [Web] (Golden Rice Organization, 2006 [cited October 8th 2006]); available from http://www.goldenrice.org/Content1-Who/who_Gary.html.
[117] Ironic as it may be, the 'bug' metaphor which completes a full circle of appropriation here, is today mostly associated with computer programs and not biological systems.
[118] Jefferson Interview

innovation in the future would benefit tremendously from the ability to integrate the work of plant breeders and molecular biologists. Moreover, he believed that it was high time for the ideas and techniques developed by molecular biologists to be put to work in the service of international agriculture. After he got a small office in a Canberra building that occupied the plant-breeding scientists of the Australian national science agency, CSIRO, he incorporated the Center for Application of Molecular Biology to International Agriculture as a not-for-profit Australian company, getting ready to bring the benefits of molecular biology to plant breeding. CAMBIA's resources at its inception were scarce; it had no budget, no labs, not even a telephone. Soon, however, Jefferson befriended the maintenance people at CSIRO and was able to get some used equipment and turn his office into a small lab. Toenniessen, impressed with Jefferson's industriousness, agreed to double his budget. Jefferson hired a few people and started developing his connections with his neighbors at CSIRO and the Australian National University, and deepened his connection to the Rockefeller Foundation, which has been one of CAMBIA's main backers ever since. He also made early connections with other funders like the Dutch government, which would prove fruitful in later years.

In the following year, while trotting around Asia's rice programs, Jefferson developed his vision and a multi-year roadmap for CAMBIA. The plan is articulated to its full capacity in a 1993 journal article that Jefferson co-authored with CAMBIA's senior scientist at the time, Kate Wilson.[119] The paper develops a coherent philosophy and articulates a far-reaching vision. It argues that agricultural sustainability and innovation require local empowerment because in ecology and agriculture the locality

[119] R. A. Jefferson, "Beyond Model Systems: New Strategies, Methods, and Mechanisms for Agricultural Research.," *Biotechnology R & D Trends (in Annals of the New York Academy of Sciences)* 700 (1993): 54.

of the system creates complexity that cannot be overcome by traditional models. The policy imperative, then, is what Jefferson later calls a '3D' strategy, which holds Democratization, Decentralization and Diversification as the basic tenets of social, economic, and environmental responsibility. The paper further argues that long-term innovation, sustainability, and productivity in crop development will only be achieved by *integrating* the labs and the fields and not by separating them:

> …new tools that can be wielded by farmers and local agricultural and environmental researchers to assist them in understanding the complexities of their own local agricultural systems are needed. Until recently, there was no organization with the specific remit to develop such tools, and it falls well outside the financial and other constraints of previously existing private and public organizations. CAMBIA will fulfill this role, and by working in partnership at all levels to develop such tools it will benefit the agricultural community and those who depend upon it throughout the world. [120]

What this meant in practice was that CAMBIA planned to pursue activities in all levels of research including molecular genetics, field and environment analysis, adaptation and implementation of crops to local conditions, and more. In addition Jefferson planned for a score of supporting activities including education, communication, infrastructure development and the establishment of a "Molecular Genetic Resource Service." The paper also outlines some specific projects, which might seem to border on delusion. For example, it talks about *sentinel plants*, or plants that would be genetically engineered to change their color in the presence or absence of certain chemicals, say nitrogen or phosphates, in the soil. Using such plants farmers could rely on local fertilization techniques and would have to rely less on purchased inputs of agro-chemicals. The paper also outlines a strategy for developing techniques to control Apomixis, a phenomenon by which seed is formed without fertilization of

[120] Ibid.: 73.

the gamete by pollen.[121] The technology to develop sentinel plants and to introduce Apomixis to a wide variety of plants is available, the paper argues. What is lacking is the political will to use complicated biotechnologies in order to build simple tools that could be used in a simple, non-destructive manner, in the fields of the developing world. CAMBIA's next few years were committed to realizing this vision, which to date, still has not materialized.

In order to understand the CAMBIA's vision and its discontinuities from the realities of proprietary agricultural innovation, I have to now take a detour and discuss the course which agriculture had taken during the twentieth century.

From the Green Revolution to the Gene Revolution

Speaking broadly, in the developed world, starting in the 1850s, agriculture morphed into agribusiness.[122] What used to be primarily a small-farm, family run sector has become an industrialized, corporate-controlled form of business, organized into integrated networks of agricultural inputs and outputs controlled by a small number of large corporations. The clearest outcomes of this transition were (a) a reduction in the workforce devoted to agriculture to the point where in the developed

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[121] Ibid.

[122] The term 'agribusiness' in this context refers to the aggregate of the agricultural input sector, the agricultural production sector, and the processing-manufacturing sector: farmers, providers of farm inputs, processors of farm outputs, manufacturers of food products, and those who transport, sell, and/or prepare food products. The term was first popularized in John H. Davis and Ray A. Goldberg, *A Concept of Agribusiness* (Cambridge, MA: Harvard University Press, 1957). For an overview of the transition of agriculture and an introduction to agribusiness see Cliff Ricketts and Omri Rawlins, *Introduction to Agribusiness* (New York: Thomson Delmar Learning, 1999), Chapter 1-3. For the history of agribusiness in the early twentieth century, see Donald J. Pisani, *From the Family Farm to Agribusiness : The Irrigation Crusade in California and the West, 1850-1931* (Berkeley: University of California Press, 1984).. See also Mary Neth, *Preserving the Family Farm : Women, Community and the Foundations of Agribusiness in the Midwest, 1900-1940*, *Revisiting Rural America* (Baltimore: Johns Jopkins University Press, 1995). For further reference, Iowa State University's Center for Agricultural History and Rural Studies offers and extended American agricultural history bibliography, see *Extended American Agricultural History Bibliography* [Web] (Iowa State University's Center for Agricultural History and Rural Studies, 2008 [cited Jan 15 2008]); available from http://www.history.iastate.edu/agprimer/Page13.html.

countries framers now account to a mere few percent of the total workforce compared to over 60% in the world's least developed countries; (b) an increase in crop yields and overall food production; (c) an increase in the overall quality of food; and (d) a concentration of control over essential food-production technologies in the hands of private sector businesses.

Agriculture's morphing into agribusiness is correlated with its evident technologization. In the last six decades technology in general, and biotechnology particularly, are playing growing roles in agriculture. An early manifestation of this trend can be found as early as 1945 when the Mexican government and the Rockefeller foundation, which is a significant actor in this story, set out to help out poor Mexican farmers to increase their wheat production.[123] As recalled by Norman Borlaug, one of the key scientists involved in the "Green Revolution," who received the Nobel Peace Prize in 1970 for his lifetime work helping feed the world's hungry, the outcome of twenty years of research in the fields was a high-yield wheat crop that resisted a variety of plant pests and diseases and yielded two to three times more grain per unit of land than traditional varieties.[124] As a result, Mexico soon became self-sufficient in grain production. The experience gained was exported to Colombia, India, and the Philippines with similar results. In 1968, William Gaud, director for the U.S. Agency for International Development (USAID) wrote in his annual report that he was witnessing a "green revolution" in the fields of developing countries and the name stuck ever since.

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[123] Rockefeller's work was significant in related fields too, including the development of DDT. See Darwin H. Stapleton, "A Lost Chapter in the Early History of Ddt: The Development of Anti-Typhus Technologies by the Rockefeller Foundation's Louse Laboratory, 1942-1944," *Technology and Culture* 46, no. 3 (2005). Deborah Fitzgerald offers a critique of the Rockefeller Foundation's program. She argues that it failed where the American model of agricultural progress did not fit Mexican conditions. See Deborah Fitzgerald, "Exporting American Agriculture: The Rockefeller Foundation in Mexico, 1943-53," *Social Studies of Science* 16, no. 3 (1986).
[124] *Biotechnology and the Green Revolution: Interview with Norman Borlaug* (ActionBioScience.org, 2002 [cited 08/07 2006]); available from http://www.actionbioscience.org/biotech/borlaug.html.

Since the 1960s the concepts of the Green Revolution were implemented in more developing countries in Latin America and Asia, which as a result experienced a drastic increase in crop yields and a drastic reduction in the input of human labor to agriculture.[125] Among others, these efforts relied on techniques that included extensive use of chemical fertilizers, perfection of efficient methods for irrigation that allowed multiple crop cycles per year, the use of heavy machinery in every aspect of farming, reliance on new pesticides and herbicides, and perhaps above all else, the development and distribution of better seeds.

The green revolution was an orchestrated effort that included science, technology, education and policy. In the 1960s critics had already started questioning the long-term effects of these modern techniques on the environment and the global ecology,[126] but little attention was given to the underlying paradigm shift in plant breeding and the beginning of massive consolidation in the agricultural sector.[127] Under the radar of ecologists and environmentalists, ever-growing agricultural firms were amassing power using both technological and legal tools.

Seeds have always afforded both a means of production, and in their identity as grains, the end product in and of itself. Based on these affordances, for ages, farmers saved some small percentage of the yearly yield and used it as the basic input for the following years' crop. In order to improve their crops farmers would locally select what they believed were better seeds as the basis for next year's planting, and they

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[125] An exhaustive bibliography and general overview summarizing influences, successes, social and economic impacts, and failures of the Green Revolution is given in M. Bazlul Karim, *The Green Revolution: An International Bibliography* (New York: Greenwood Press, 1986).
[126] A detailed summary of the multiple aspects of the Green Revolution is available in Clifton R. Wharton, "The Green Revolution: Cornucopia or Pandora's Box," *Foreign Affairs* 47, no. 3 (1969). Rachel Carson's *Silent Spring*, for example investigated the role that pesticides played in unbalancing the bird-pest ecosystem, and is cited as one of the classic texts of environmentalism. See Rachel Carson, *Silent Spring* (London: Hamilton, 1963).
[127] Thierry Bardini presents an interesting study from a Science Studies perspectives that questions the failure or success of the Green Revolution. See Thierry Bardini, "A Translation Analysis of the Green Revolution in Bali," *Science, Technology & Human Values* 19, no. 2 (1994).

would engage in seed-exchange with neighboring farmers in order to increase variety. The United Nations' Food and Agriculture Organization estimates that in developing countries these practices still constitute up to 90% of the sources for seeds.[128] However, for developed countries these traditions that had worked for thousands of years produced only modest improvements, which seemed lacking in the face of growing populations in the late nineteenth century. As a result, a sector of plant breeders and seed-improvers appeared, consisting of farmers and agronomists whose role was not the production of crops but, rather, the perfection and distribution of seeds. Included within this group are both private seed breeders who sought business in this sector as a private enterprise, and, particularly in the U.S., with its land-grant university complex, government sponsored plant breeders.[129] Importantly, seed saving and exchange traditions became incongruent with the capitalistic visions that were beginning to dominate agriculture around that time, and would soon be banned.

For the capital-driven enterprises in this group, seed saving traditions posed an economic problem: farmers could purchase improved plant varieties and then re-use or even propagate them using natural breeding cycles, undermining incentives for investment in crop improvement. Over the years, commercial seed producers found two solutions to this problem: the first was code-based—the introduction of hybrid varieties; the second was law-based—enhancing breeders' rights and increasing legal protection at the expense of the farmers' traditional seed-saving and exchange rights.

Based on the principles of Mendelian hereditary transmission of traits, *hybridization,* was invented in the U.S. in the 1930s. It involves a systematic cross-

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[128] For an overview of the farmer seed system see Temba M. Musa and Harare Borrowdale, "Farmer Seed Systems" (paper presented at the International workshop on developing institutional agreements and capacity to assist farmers in disaster situations to restore agricultural systems and seed security activities (Project GCP/INT/660/NOR), Rome, Italy, 3-5 November 1998).

[129] J.R. Jr. Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology*, 2nd ed. (Madison, WI: University of Wisconsin Press, 2005), 65.

pollination of plants with the expressed purpose of producing new varieties with specific characteristics. The process of hybridization itself is complicated and requires the development of multiple lines of a plants in carefully controlled methods of cross-pollination over several plant generations. It is thus practically impossible to hybridize on a local farm; only specialized seed-producing farms can produce hybrid seeds. Deborah Fitzgerald argues that: “hybrid corn was an agent by which farmers were effectively deskilled...If the farmer is viewed as a laborer who possesses a set of manual and mental skills, then hybrids were perhaps more profoundly deskilling than any mechanical implement”.[130]

Importantly, these transitions of the ‘code’ could be viewed as shifts in an information economy. I read hybridization as the first important step of a process that turned seeds into KEGs. Hybrid seeds were not just seeds: they were containers of knowledge. Moreover, this ‘code’ change co-develops with a market change too. In his extensive review of the history of plant biotechnology, Kloppenburg reviews the economic implications of hybridization, arguing that “hybridization opened to capital a whole new frontier of accumulation that commercial breeders moved rapidly to exploit.”[131] The separation of grain and seed in the crossover from open-pollinated to hybrid varieties requires farmers to purchase seeds year after year. Unlike seed-saving traditions, seed-purchasing is a market transaction which requires farmers to obtain sufficient working capital by participating in a money economy that involves activities like the sale of their crops for money, the securing of credit lines and loans, and the general aggregation of financial resources. These activities, in turn, clearly call for economies of scale and promote consolidation and corporate farming over more

[130] Deborah Fitzgerald, "Farmers Deskilled: Hybrid Corn and Farmers' Work," *Technology and Culture* 34, no. 2 (1993): 327.
[131] Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology*, 11.

traditional methods. It is important to note, as Kloppenburg emphasizes, that the historical path that favored the hybrid model is not a matter of scientific discretion but, rather, the result of political-economic configurations that favored hybrids for the economic advantages they offered to commercial seed-producers and agribusiness.[132] This trend is exacerbated when more and more aspects of agriculture become dependent on centralized farm-input production such as seeds and fertilizers.

In the mid 1950s, DNA was being studied and the double helix was introduced into the scientific imagination imbuing new meaning into abstract genes.[133] In a sense, hybridization gave only a taste of what would come as soon as plant breeding started using recombinant DNA techniques that were invented in the 1970s, when an arms race of sorts ensued among would-be biotech companies, which aimed to manipulate the genetic code of plants and animals in search of favorable, more marketable plant characteristics.[134] The genetic biotech era had begun. It took two more decades, but eventually the first genetic-biotech-based crops were introduced to the fields in the late 1980s and commercialized by the early 1990s.[135] Since then, a wide variety of GMOs have been planted around the world, starting fierce debates between advocates and adversaries about the legitimacy, moral, economic, and environmental impacts of these crops; this debate will be referred to hitherto as the GMO debate. The main

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[132] Ibid., 129.

[133] Evelyn Fox-Keller describes the transformation of the abstract concept of a 'gene' that was introduced by Wilhelm Johannsen in 1909, and the way that the field of molecular genetics was reliant on the gene paradigm. Keller presents a powerful argument on the limits of simplistic genetic concepts. See Evelyn Fox Keller, *The Century of the Gene* (Cambridge, MA: Harvard University Press, 2000), Ch. 1-2.

[134] For a brief history of biotech discoveries which continue to influence the field today and an integrated series of time lines which provide an overview of biotechnology's history see *Biotech Chronicles* [Web] (National Museum of Health, 1999 [cited 08/08 2006]); available from http://www.accessexcellence.org/RC/AB/BC/.

[135] The first crop to be commercialized was Calgene's infamous 'flavor savr' tomato that reached the fields in 1994. It had since been taken off the market. See *Genetically Engineered Foods: Tomatoes* [Web] (Cornell Cooperative Extension's Genetically Engineered Organisms Public Issues Education, 2003 [cited 08/09 2006]); available from http://www.geo-pie.cornell.edu/educators/downloads/fs7_tomato.pdf.

focus of my work is clearly not to evaluate the different arguments on both sides of this debate, so I will largely abstain from any substantive judgment about it, but I will explore the ways in which openness to volunteer participation plays out in this argument.[136] As I will explain below, several of the actors think that this debate has long ago become politicized. As a matter of method, I do not aim to separate the political from the scientific. I will later explore the changing norms around GMO's, how BIOS aims to change them, and what this means for democratic culture. Suffice it to note here that genetically engineered crops represent yet an extra step in the turning of agricultural products into KEGs. A genetically modified tomato like Flavor-Savr™, for example, which was the first GM crop to reach the fields in 1994, includes not only its meat but also the knowledge embedded in it. To that extent it becomes the focus of both knowledge claims and intellectual property protections. In other words, the changes in the 'code' that were introduced by biotechnology open the door for new regulations by 'law'. Importantly, as I argue throughout this work, what the law can protect and what areas of life it can regulate is itself a social struggle between different social groups. And indeed, as much as the code, markets, and norms around agriculture changed in the twentieth century, so did the law, which I survey next.

In addition to perfecting technologies like hybridization that protect their interests, plant breeders have used their power to constantly expand the scope and benefits of Intellectual Property Rights (IPR) protections as well. Under the traditional

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[136] There is a wide body of literature in Science Studies on the GMO debate. S&TS has been primarily concerned with the ways in which the debate has been constructed, the ways GMOs become traceable and the ways in which different governments take different approaches to regulate GMOs. See Joseph Murphy, Les Levidow, and Susan Carr, "Regulatory Standards for Environmental Risks: Understanding the Us-European Union Conflict over Genetically Modified Crops," *Social Studies of Science* 36, no. 2 (2006), Javier Lezaun, "Creating a New Object of Government: Making Genetically Modified Organisms Traceable," *Social Studies of Science* 36, no. 4 (2006). For a comprehensive discussion of the political, economic, environmental and development controversies, see Gerald C. Nelson., ed., *Genetically Modified Organisms in Agriculture : Economics and Politics* (San Diego, CA: Academic Press, 2001).

legal doctrine, genetic resources formed part of a global commons and were **not** subject to intellectual property claims. This interpretation was eroded over the last 25 years, as more and more aspects related to agriculture fell under the scope of ever-expanding IPR claims.[137] This was primarily caused by (1) the extension of patents to living organisms and genetic materials and (2) the negotiation of a complex set of international treaties that promote the expansion of plant breeders' rights (often at the expense of farmer's rights). Patents are the key to these protections, but trade secrets, plant variety protection mechanisms, and forceful contracts play a determining role as well. This process of ever-increasing protections results in a situation whereby genetic resources are no longer considered a part of a global commons.

The landmark 1980 case of *Diamond vs. Chakrabarty* had served as the precedent for a series of further rulings. In a close five to four decision, the U.S. Supreme Court upheld that man-made microorganisms are patentable. The court wrote that patents could be issued for "anything under the sun that is made by man"[138] and that the relevant distinction is not between living and inanimate things, but, rather, between naturally existing and human-made inventions. Most developed countries adopted this legal philosophy and today in almost all industrialized nations patents can be issued for microorganisms, genetically modified plants and animals, isolated and purified genes, and genetic sequences. The ability to patent genes is significant because the holder of a patent on an isolated and purified gene can prevent all others from making or using that gene during the patent's duration (typically, twenty years). This means in practice that patents can prevent independent invention and block external attempts to improve crops. Exclusion from independent invention is true for

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[137] For in-depth analysis of this subject see Shay David, "Peer-Production for Development: The Case of Agri-Biotech," in *Access to Knowledge*, ed. J. M. Balkin and Y. Benkler (New Haven, CT: Yale University Press, forthcoming).
[138] *Diamond Vs. Chakrabarty*, 447 US 303, 16, (1980).

patents in general, but as they pertain to genes, patents pose a particularly high barrier because genes are such a fundamental unit. Whereas in other cases such as, say, industrial design, there might be ways to invent around a patent, in case of genes that control crop traits such as protein levels, it is very hard if not impossible to bypass the patented gene. Cornell University plant breeder Ronnie Coffman, for one, invokes an analogy to explain the dangers in this situation. He argues: "If words were copyrighted, only a few who owned them could communicate and our society would be harmed. Genes are analogous to words in that they allow the creation of new plant cultivars just as words allow the creation of a book. Everyone in society should have the right to use genes…it is now clear that the patenting of genes will result in only two or three companies having a major influence on the food system."[139]

Although IPR had traditionally been an area of national sovereignty and lawmaking, over the last several decades it has become inextricably bound by a complex set of international agreements, treaties and conventions, negotiated in various international fora. Many of the resulting agreements are controversial, reflecting in their vague language or underspecified rules and enforcement mechanisms the competing interests of signatories with significantly different levels of development.[140] Perhaps more than any other international treaty in recent years, the 1994 agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), a part of the agreement that allowed the formation of the World Trade Organization (WTO) has had, and continues to have, a dominant influence on the legal landscape

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[139] Coffman quoted in Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology*, 349.

[140] For an in depth discussion of the issues overviewed here briefly, see detailed discussion in Group Crucible, ed., *Seeding Solutions: Policy Options for Genetic Resources: People, Plants, and Patents, Revisited*, vol. 1 (Ottawa, Canada: IDRC Books, 2000), 89. See also Christophe Bellmann, Graham Dutfield, and Ricardo Meléndez-Ortiz, eds., *Trading in Knowledge: Development Perpsectives on Trips, Trade and Sustainability* (London, UK: Earthscan Publications, 2003).

governing food security.[141] TRIPS brings intellectual property rights to center stage in international trade negotiations. Of particular interest to us is Section 27, which requires that signatory states adopt a national level intellectual property rights protection system for all products and processes, including pharmaceuticals, modified microorganisms and microbiological processes. Since TRIPS is part of international trade agreements, unlike earlier international conventions dealing with intellectual property, which were often toothless, it offers both sticks and carrots to signatories. TRIPS is the basis of a process of 'harmonization' of intellectual property rights that has forced developing countries to adopt the standards of protections that are accepted in the West, including, in this case, strong protections for seeds, plant varieties, microorganisms, and relevant biotechnological tools. As I will show, the protections of essential farm inputs and technologies are painful thorns in the flesh of the developing world. A side effect of attempts to increase return on investment in core markets limits the ability of developing countries to enjoy and improve crops that are not profitable in developed-world terms. Whether they like it or not, developing countries are subject to IPR claims by multinational corporations. In large part, the open agricultural innovation models that are the focus of this case study are aimed at alleviating these pressures.

Agricultural Innovation meets Open Source

For most of the 1990s CAMBIA's staff was working on implementing the strategy that Jefferson articulated in 1993. The scientific results soon followed,

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[141] TRIPS is administered by the World Trade Organization (WTO) which sets down minimum standards for most forms of intellectual property (IP) regulation. It was negotiated at the end of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) treaty in 1994. For the treaty's text see *Agreement on Trade-Related Aspects of Intellectual Property Rights* (World Trade Organization, 1994 [cited 08/19 2006]); available from http://www.wto.org/english/docs_e/legal_e/legal_e.htm#TRIPs.

followed by articles published in the most prestigious journals of plant sciences, showing different applications for the GUS reporter gene and exploring the potential for Apomixis.[142] But the political results were lagging. Despite several years of hard work in these areas, the uptake of CAMBIA's technology within the plant breeder community has not been as rapid as Jefferson had hoped. Jefferson noted that the climate has changed since his GUS experience; increasingly, both private and public research centers were now more cautious about cooperation and sharing of research results and materials. There were two primary reasons for this change. The first was the enactment by the U.S. congress of the Bayh-Dole act[143] in 1980 that permitted public universities to pursue intellectual property protections for federally funded research. This law created a surge in private-public partnerships and the closing up of previously open science by entities that wanted to commercialize university research. It took more than a decade for Bayh-Dole to become the norm, but after it did both public and private U.S. research centers became much more sensitive to IPR issues. (See the detailed discussion on Bayh-Dole in the section below on PIPRA and publicly funded university research.) The other reason was the change in the international legal landscape and the harmonization of IPR regimes across the globe, which forced developing countries to adhere to the standards of the West in offering protections to biological innovations. By the end of the 1990s, many more players were playing in what Peter Drahos has dubbed 'the knowledge game' in which the ability to create pockets of proprietary knowledge and protect them using technological and legal regimes becomes a fundamental basis for achieving commercial advantages.[144] These

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[142] For a complete list of publications see *Cambia: Papers and Publications* [Web] (CAMBIA, 2006 [cited November 8th 2006]); available from http://www.cambia.org/daisy/cambia/publications.html.
[143] See discussion above, and *Bayh-Dole Act (Rights to Inventions Made by Nonprofit Organizations and Small Business Firms under Government Grants, Contracts, and Cooperative Agreements)*.
[144] Peter Drahos and John Braithwaite, *Information Feudalism: Who Owns the Knowledge Economy?* (New York, NY: W. W. Norton, 2003), Ch. 3.

changes produced a situation in which IPR considerations could no longer be separated from plant breeding or from the food security problem.

Perhaps more than in any other case in recent years, these complexities come to the fore in the cautionary tale of GoldenRice™. In an attempt to alleviate a disease called Vitamin-A Deficiency (VAD), which is a leading cause of death and blindness in the developing world, the Rockefeller foundation funded research whose objective was inserting several genes into rice, which does not naturally contain Vitamin A, in order to produce an improved variety called GoldenRice™, which would allow people who rely on rice as their staple crop to get the vitamins they needed so desperately. GoldenRice™'s promise was (and still is) to alleviate the VAD problem in an effective, inexpensive, and sustainable way. The research lasted for over 15 years from the mid-1980s to about 2000 with promising results. Several other funders, including the European Union (and later the Gates foundation) joined, and large corporations too, but when it became time to commercialize GoldenRice™ and introduce it to the fields, legal problems surfaced in the form of an inextricable nexus of intellectual and technological property claims by the dozens of bodies that were involved in GoldenRice research. The inventors of GoldenRice™, Ingo Potrykus, working at the Institute of Plant Sciences at the Swiss Federal Institute of Technology, and Peter Beyer of the University of Freiburg made use of over 70 protected elements belonging to 32 different entities in the creation of golden rice.[145] Over the years over a dozen other players participated in the research and by the development's end these players owned --or claimed to own-- patent rights, plant variety protection certificates, unpublished patent applications, inventions, improvements, and/or discoveries that may or may not have been legally protectable, trade secrets, research plans, research

[145] I. Potrykus, "Golden Rice and Beyond," *Plant Physiology* 125 (2001).

results and related reports, statistical models and computer programs, germplasm and biological materials pertaining to GoldenRice™.[146] The bottom line was that none of the players had enough of the IPR to facilitate a widespread release, transfer and use of GoldenRice™ without acquiring licenses from the other parties. Negotiating such a deal, however, proved to be too complicated and expensive for any of the public organizations who might have had the power to disseminate GoldenRice™, and was further complicated by the target countries' different IPR regimes, which acknowledged or ignored certain claims. Consequently GoldenRice™ could not reach the fields. This was unacceptable to the inventors and the funders that had spent fifteen years and millions of dollars on the project. With their mediation an agreement was reached with a conglomerate called Zeneca (now part of Syngenta) to give up its IPR claims and transfer them to a smaller firm that would sign similar agreements with the smaller players that would follow suit. In 2004 GoldenRice™ finally went into field trials. Although Zeneca has no commercial interest in GoldenRice™ because the crop has no market in the developed world where wheat is the prime staple, it didn't want this to be a precedent for it giving up rights, so the rights were granted as part of a 'humanitarian license', which stipulates that the use of GoldenRice™ will be free only to farmers making less then US $10,000 annually.[147] In sum, this story teaches us a lesson on the intricacies of IPR regimes in an international setting and on how these cannot be separated from the work in the fields and the labs.

Of all people, Richard Jefferson didn't need GoldenRice™ in order to identify these problems, nor does he think that GoldenRice™ is necessarily the most

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[146] D. Kryder, S.P Kowalsi, and A.F. Krattiger, "The Intellectual and Technical Property Components of Pro-Vitamin a Rice (Goldenrice™): A Preliminary Freedom-to-Operate Review," in *ISAAA Briefs* (Ithaca, NY: International Service for the Acquisition of Agri-biotech Applications, 2000).

[147] *Golden Rice Project Faq* [Web] (Golden Rice Project Board, 2006 [cited October 22nd 2006]); available from http://www.goldenrice.org/Content3-Why/why3_FAQ.html. see also Wikipedia: Golden Rice, Visited 10/20/06.

compelling example when explaining the problems of the field. The real problem, he believes based on CAMBIA's work in similar areas of crop improvement, is the growing disparity between the haves and have-nots. In his view, the real problem is the fact that a can of Coke™ costs more than the daily salary of over a billion people. The problem is exacerbated by the constant expansion of this disparity. Instead of using new technology to help those who need it most, Jefferson argues, the reverse happens. He explains:

> The existing innovation system in biological sciences encourages the private appropriation of critical enabling technologies through intellectual property rights, typically patents. Increasingly, biological technologies are not self-contained, but instead are interdependent technologies requiring multiple key components to function to the point of delivery. Denial of access to any component prevents the use of the technology. With the massive increase in patenting of biological processes and materials, securing a pathway to delivery is virtually insurmountable by any but the most powerful corporations. For these entities, only the highest margin products merit attention, and thus they are not targeting products of interest to many smaller, less capital-rich markets.[148]

While the powerful corporations believe that the problem could be solved using market forces and/or sophisticated humanitarian licenses where they are needed, BIOS presents an alternative.[149] Jefferson highlights the pattern that has come to characterize 'humanitarian licenses': rights are granted to the poor farmers so long as they stay poor (and the GoldenRice license is a case in point).[150] What is needed, then, from BiOS's point of view, is a system that could challenge the existing political economy of biological innovation. This is where the open source movement comes into the picture.

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[148] *Bios Faq* [Web] (BIOS, 2006 [cited October 22nd 2006]); available from http://www.bios.net/daisy/bios/about_BiOS/27.html.
[149] For a discussion of the economic aspects, see David Opderbeck, " The Penguin's Genome, or Coase and Open Source Biotechnology," *Harvard Journal of Law and Technology* 18, no. 167 (2004).
[150] Jefferson interview.

When he first encountered FOSS, Jefferson had been developing his vision for over a decade but the uptake was slower than he hoped. He realized that the FOSS movement provided the perfect example of what he was trying to achieve, in a different field. FOSS offered a fresh illustration of how small players can disrupt an otherwise stable sector. FOSS provided models for the organization of distributed labor as well as alternative legal regimes that could challenge hegemony. Combined, these models provided an economic logic that was attractive to volunteers and industry players alike. Stallman and Torvalds, like the many other FOSS project originators and their followers, aimed to and succeeded in changing the political economy of software; the embrace of FOSS within the software sector was hard to argue with. Jefferson was inspired. He had not met any of the leaders of the free and open source software movement—he had hardly even heard of them, he acknowledges in an interview—and he had never participated in an open source project before, but the more he came to understand the open source software model, the more he realized how similar it was to his vision for biological innovation. The conclusion followed directly: CAMBIA could restate its long held objectives using the proven terminology of the FOSS movement and thus enjoy FOSS's aura of success. By accepting FOSS as a model CAMBIA hoped to find models for volunteer labor organization as well as a basic legal framework necessary. In later years CAMBIA would take a step further and actually try to recruit volunteers in FOSS conferences and events.[151]

The result of this effort was the creation of the BIOS initiative. As an acronym, BIOS, stands for "Biological Innovation for an Open Society" but conveniently could also mean "Biological Open Source."[152] In both written material and oral discussions people I've talked to often confuse the two meanings. CAMBIA started BIOS with the

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[151] Jefferson interview.
[152] 'bio' means 'life' in Greek

objective to adapt licensing and distributive collaboration aspects of the software open source paradigm to the field of biological innovation. To this extent, BIOS is centered around three main areas of activity that together are designed to enhance transparency, accessibility and capability to use patented technologies, know-how and materials in a biological/agricultural context. These areas are described next.

BioForge

The first area of activity is about ‘code’. BioForge is a central clearinghouse for biological innovation projects.[153] It allows any registered user to suggest and mange projects, and provides tools for progress monitoring and documentation. BioForge is modeled after SourceForge.net the software parallel, which, as discussed in chapter 3, hosts tens of thousands of software projects. BioForge offers a dynamic database-driven website for organizing activities around enabling technologies that will one day be available to the worldwide inventive community for use in improvement and new innovations through specially constructed BIOS licenses. Examples of key projects that are managed in BioForge include the following:

- TransBacter.™ As recently published in Nature,[154] TransBacter is a method for creating genetically modified crops that does not infringe on patents held by big biotechnology companies, particularly Monsanto. The new method allows transferring genes to plants using several bacteria other than Agrobacterium-tumefaciens (aka At), for which Monsanto holds a patent and which until recently had been considered the only microbe capable of such gene transfer. By patenting At, which was believed to be the only bacteria that could be engineered to transfer genes from source to target organisms, Monsanto gained a chokehold on an

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[153] *Bioforge Homepage* [Web] (CAMBIA, 2006 [cited October 24th 2006]); available from http://www.bioforge.net/forge/index.jspa.
[154] Wim Broothaerts et al., "Gene Transfer to Plants by Diverse Species of Bacteria," *Nature* 433, no. 10 (2005).

essential element in modern plant breeding.[155] After careful examination of the patent claims surrounding At, Jefferson discovered that they all depended on the use of this particular bacteria. Using another bacteria, it became clear, would circumvent the patent thicket, and that is exactly what TransBacter does by using a 'cousin' bacteria to do what normally At does.[156] CAMBIA hopes that in the future the TransBacter technology could be distributed not as bacteria but as DNA. What this would mean is that labs interested in gene transfer could use CAMBIA's DNA to engineer bacteria like E. Coli, the workhorse bacteria of biology labs, to do gene transfer work. This would greatly simplify gene transfer both technologically and legally.

- GUSPlus™. This project represents the next generation of GUS reporter/marker genes, allowing improvements to existing techniques of visual inspection of gene transfer. GUSPlus is distributed to users as DNA vectors. There are GUSPlus vectors for checking transformations and screening transformants, and special vectors for use with TransBacter strains. Figure 6-1 shows a GUSPlus expressed in rice.
- Diversity-Arrays (DArT™). DArT is a genotyping technology that enables rapid and relatively cheap analysis of plant and animal genomes without prior DNA sequence knowledge. DArT's importance stems from the possibility of using it for analyzing genes for small-market crops and species, for which analsis in existing techniques would be expensive.[157] DArT was invented in 1996 by Andrzej Kilian, then director of Genomics at CAMBIA, when he realized that genotyping

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[155] At transfers genes by physically inserting genetic material in to target cells using a 'needle' of sorts that it attaches to the cell. In nature At uses this technique in order to induce the growth of its food source. In the lab At can be tricked into transferring any gene to the target.
[156] R. A. Jefferson, *Transbacter - Detailed Description and Protocols* [Web] (CAMBIA, 2006 [cited October 27th 2006]); available from http://bioforge.net/forge/entry.jspa?externalID=21&categoryID=2.
[157] Marie Connett, *Dart Overview* [Web] (CAMBIA, 2006 [cited October 27th 2006]); available from http://bioforge.net/forge/entry.jspa?externalID=51&categoryID=4.

technologies developed to explore the human genome were not applicable to agriculture. Kilian was looking for a tool to detect a large number of genetic differences between varieties of rice and wheat, hence the name ‘diversity’ in the tool’s name. After building a proof of concept Kilian spun a private company off of CAMBIA, to develop the technology further. CAMBIA initially supported this effort but later decided to reclaim ownership of the project.

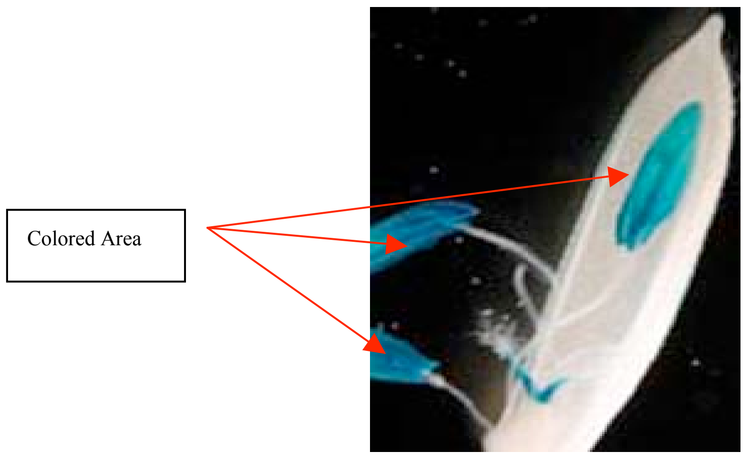

Figure 6-1: Rice anthers and style showing GUSPlus expression[158]

As in SourceForge, in BioForge too, anyone with an Internet connection can register and get access to protocols and articles. People with knowledge in biotechnology can participate in the discussions. As in SourceForge, each project has a maintainer—in BioForge the title for this role is ‘curator’—and participants can self-select projects to work on. Each project’s homepage includes additional information, news, and more. Unlike SourceForge, however, in BioForge there is no ‘source code’ to download, rather, material samples can be ordered with a special form, and shipped

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[158] Source: *Gusplus(Tm) Overview* [Web] (CAMBIA, 2006 [cited October 24th 2006]); available from http://www.bioforge.net/forge/entry.jspa?externalID=41&categoryID=3.

by regular mail.[159] Perhaps the most striking difference between the two networks, however, is their size and maturity. SourceForge is used to manage tens of thousands of projects, and active projects have hundreds of participants. BioForge, still in its infancy, boasts only 13 projects and a few dozen users (January 2008). All the projects to date are managed by CAMBIA employees, and there seems to be little community activity in the form of active discussions or contributions from other volunteers. In other words, at this point in time, BioForge is more a dream than a reality. The project is too young to assess whether the level of activity will remain low or whether it can grow as rapidly as SourceForge did. Some scholars suggest that the real use of biological open source project like this is not necessarily for agriculture, but for curing diseases.[160] Some of BioForge's users suggest that it's just a matter of time until enough basic building blocks are in place (see discussion below). Clearly however, the barriers to participation in BioForge projects are much higher than in the software parallel. In SourceForge, users who are not programmers, can participate by downloading software and reporting bugs. Very little specialized knowledge is required for this. In BioForge in contrast, the available tools offer little value for anyone that is not immersed in specific molecular biological activities such as gene sequencing. In SourceForge many of the projects are complete software packages, that enable extensive functionality to the end users. In BioForge most of the projects focus on tools, such as vectors or reporter genes, which do not stand on their own but rather are designed to be part of a bigger process. Above all, the key difference is the environment in which biotechnology is practiced. In contrast to most software projects that require little more than a personal computer in order to start and experiment,

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[159] In the future, with the advent of synthetic biology, there might be a way to download sequences and synthesize them in the lab without ever needing to ship any material.
[160] Stephen M. Maurer, Arti Rai, and Andrej Sali, "Finding Cures for Tropical Diseases: Is Open Source the Answer?," *PloS Medicine* 1 (2004).

molecular biology is not practiced in the kitchen. Theoretically speaking, many of the projects offered by BioForge can be implemented using household kitchen equipment, but in reality very few people have biotech labs at home. All these reasons together suggest that BioForge might never enjoy the massive participation that SourceForge enjoys.

BiOS licenses

The second area of activity is focused on 'law'. The BIOS license family is a set of legal agreements that are designed to facilitate simple and straightforward mechanisms for creating a 'protected commons' and for controlling the sharing of patented and non-patented technologies, materials, and methods.[161] In other words, BIOS licenses are designed to support freedom to operate and to cooperate.[162] When accepting the terms of a BIOS license, licensees must agree to legally binding conditions in order to gain access to the protected commons. BIOS licenses take their inspiration from the Copyleft licenses discussed in Chapter 3, and like them employ a 'viral' clause, which typically stipulates that improvements to the shared technologies should be shared under similar conditions. This guarantees that licensees could not appropriate the fundamental "kernel" of the technology and improvements exclusively for themselves. There is a fundamental difference, however, between BIOS licenses and software copyleft licenses. As I showed, copyleft is based on copyright. In biology, however, the common means of protection is patents, which protect ideas rather than expression. This necessitates changes to the license structure in order to guarantee that later patenting will not put earlier developments at risk.[163] Copyright cannot curtail independent creativity and innovation simply because the claims of a

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[161] *About Biological Open Source Licenses and Mtas* [Web] (CAMBIA, 2006 [cited 08/22 2006]); available from http://www.bios.net/daisy/bios/BiOS_licenses.html.
[162] Ibid.
[163] Marie Connett Interview

copyright holder are limited to protecting the direct forms of expression that are expressed in the copyrighted material. Patents, in contrast, are tools designed specifically to prevent independent invention, for limited times, regardless of the would-be-inventors access to the patented invention. In practice this means that innovation through imitation is very limited in biology. In the world of software, me-too strategies can be used as scaffolding for supporting a nascent open source project. As I showed in Chapter 3, Stallman's GNU was a replica of Unix, designed specifically to be compatible with it. Had Unix been patented, this would not have been possible because a patent on Unix's protocols would have prevented Stallman (or any other non-licensor) from using them without permission.

This situation results in two challenges for the biological open source model. The first is that in order to offer an alternative to proprietary technologies, it has to develop a foundation that is completely free from patent claims. This is exactly what technologies like CAMBIA's TransBacter aim to do. TransBacter was specifically designed to circumvent Monsanto's patent claims around Agrobacterium and to serve as a stem on which new branches of biological innovation can grow. The second challenge is that in order to ensure its sustained openness, biological open source has to include strong protection provisions in its own licensing terms, and specifically to closely monitor the resulting innovation lest it will itself become subject to proprietary claims. The human genome project serves as a cautionary tale. With the belief that they are serving the public interest scientists were eager to release the results of the human genome mapping to the public, but among those who gained access to this valuable data were 'patent-trolls', companies that were quick to exploit the database and register patents on genes that they claimed could be the basis for future invention.[164] In order to avoid this situation, BIOS licensees must refrain from registering any proprietary rights in resulting innovation. Unlike in software, where a project's forking might take talent away from it but not endanger the viability of the stem, in a patent-based protection system if a branch forks and registers patents it can have strong exclusion effects that under some conditions could endanger the availability of the work that led to the very improvements.

BiOS licenses also take inspiration from non-open software licenses such as those used by software companies, known as shrink-wrap or click-wrap licenses. Those licenses come embedded in the packaging of the product, forcing users to accept any terms and conditions by opening the packaging. Several of CAMBIA's materials, for example, are encased in plastic envelopes, which are taped with a label on which a copy of the license is printed. By opening the envelope, the user accepts the BIOS license. BIOS licenses typically make available technologies from CAMBIA royalty-free for research and commercial purposes. For-profit companies based in developed countries are normally requested to enter into a technology subscription agreement in which they pay a small yearly fee in return to updates and support.

Patent Lens

The third area of activity in the BIOS initiative is in the field of informatics and combines 'code', 'norms', and 'law'. Patent Lens is a patent search and analysis tool, which aims to assist both professionals and non-professionals to understand and determine the intellectual property boundaries, limitations, and status of currently patented technologies.[165] The searchable database now has over 5.5 million records.

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[164] A recent article in Science estimates that over 20% of the human genome is already patented, see Kyle Jensen and Fiona Murray, "Enhanced: Intellectual Property Landscape of the Human Genome," *Science* 310, no. 5746 (2005).. For a general discussion on the negative effect patents in this field see Michael Heller and Rebecca Eisenberg, "Can Patents Deter Innovation the Anticommons in Biomedical Research?," *Science* 280, no. 698 (1988).

[165] *About Patent Lens* [Web] (CAMBIA, 2006 [cited October 24th 2006]); available from http://www.patentlens.net/daisy/patentlens/patentlens.html.

One of the most significant innovations in Patent Lens is the ability to annotate patent records with free text and links to other patents, helping those who aim to un-bundle patent thickets to make the related patent records easier to navigate. When I asked who is actually using it, one of the programmers behind Patent Lens told me that: "our logs show that both commercial and non-commercial users are using it, and in some cases personnel from the patent offices too."[166]

An additional feature in Patent Lens is "technology landscape" reports, which expand on the status of patenting concerning key technologies. Each of these reports describes key areas of plant biotechnology and the patent claims surrounding it. To write these reports CAMBIA employs scholars who have backgrounds in both IP law and life sciences. The objective of the landscapes is to translate what are otherwise convoluted legal discourses into easy-to-understand reports detailing the restrictions and limitations on key technologies. Two interesting landscapes, for example cover (a) Agrobacterium-mediated transformation of plants, focusing on patents directed to methods and materials used for transformation of plants; and (b) Molecular Markers Outside Gene Sequences, which is an analysis of so-called "junk DNA" patent claims, that make IP claims pertaining to breeding, diagnostics and other purposes. The landscapes analyze the definitions used in the claims and the prosecution history of related patents and show that the claims are not actually as broad as they may appear to be.

A third area of activity within Patent Lens is education about IPR. As one of the interviewees told me: "We believe that understanding IPR is imperative to biological innovators in both the private and public sectors… we focus on using

[166] Douglas Ashton Interview

practical examples and cases, and allowing users to educate themselves on aspects of IPR that pertain to their daily work."[167]

Summary

Taken together, through its BIOS initiative CAMBIA offers a complete model for open biological innovation which includes infrastructure for organizing labor, legal regimes to control the results of the research, educational tools to help educate the community, and key technologies that might jump-start a lab interested in biological innovation. I can now go back to the quote that started this chapter and understand it in context. In contrast to many other actors, BIOS views molecular biological plant breeding techniques not as an end in and of itself but as one element, a toolkit of sorts, in a socio-legal-technological network. In an interview Jefferson explains:

> The problem is not feeding the poor, the problem is to make the poor less poor. The problem is not producing enough calories to have the poor remain poor. The solution is not more food or better technology. The poor world needs biotech like a screen door on a submarine…Biotech can do much more than enhancing yields or protein levels in plants… For example, imagine an instrument that can guide farmers in the field when they chose nutrients and fertilizers, a tool that would cost less than $1 and would require literacy levels of a first-grader. It sounds like science fiction, but this can be achieved by planting crops that change color to describe phosphate or other elements in the soil."[168]

Bioforge and the resulting projects facilitate a participatory process of agricultural innovation that employs the existing capacity of innovation in the developing world. Under this model contributions do not only flow in one direction, from the lab to the field, but rather in both ways. While the development of enabling technologies remains the task of high-tech labs, farmers and agronomists in field stations would be

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[167] Marrie Connet Interview
[168] Jefferson Interview, October 2005

able to contribute by reporting issues arising with the use of the technologies, and by collecting and preserving germplasm from wild varieties which is essential for ongoing plant improvement. The hope is that the open innovation platform would allow multiple actors to contribute at various levels. Just like bug-reporters in software are essential to the development process, so the farmers' inputs could be essential to agricultural innovation. BioForge may allow harnessing separate groups to work towards the same ends, and BIOS licenses will ensure that the results of this effort remain open and will not be appropriated by anyone. Patent Lens in this scenario becomes the prism through which maximum freedom to operate can be achieved.

Reality check – Community and participation in biological open source

CAMBIA's vision is obviously grand, however, in actuality the uptake of all these available tools, methods, and infrastructure has been painfully slow. CAMBIA was not yet able to build the large community that it had hoped to foster. My discussions with researchers in biotech labs in several leading institutions around the world (including Haifa University, Cornell, and the University of California in Davis) show that the awareness to CAMBIA's offering is low and the technological tools that BIOS provides are still not widely spread. Data available from CAMBIA shows that so far (2008) only a few organizations[169] had bought into the model, and only one significant private sector company had signed the BIOS license agreement (BASF, see below). Moreover, several competing organizations are building their own versions of open source biology.

Further research is needed to fully assess the reasons for this slow adoption or the chances that it will ever accelerate. One interviewee, for example, noted that "".

[169] The only major research organization involved is the International Rice Research Institute, see the discussion below.

Biological open source is new compared with existing models for biological innovation, namely, grant-based publicly funded research as part of universities and international research centers, and for-profit industrial research. Relevant organizations are only now beginning to understand the scope and meaning of the new model. In addition, while CAMBIA is the leading organization advocating biological open source it is not the only body that understands the link between IPR, modes of labor organization, and agricultural innovation. In fact it operates within a whole nexus of actors and social groups that claim to be at the forefront of agricultural innovation. Naturally each of these groups brings its own understanding of the burning problems in the field and the appropriate ways to solve them. The following sections describe the activities of several of the leading actors that represent relevant social groups, their direct and indirect response to BIOS, and in some cases their attempts to offer their own version of a community working towards open agricultural innovation.

PIPRA and publicly funded university research centers

Over the last few years, publicly funded university research programs have been struggling to redefine themselves in the face of changes to the mode of agricultural innovation and the rapid shift towards the proprietary, privately funded model. Figure 6-2 shows the rapid growth of private agricultural patents in the United States over the last two decades. As the graph clearly demonstrates the private sector eclipses the public sector by a factor of three in the amounts of patents. While measuring patents as a measure of agricultural innovation is only a limited proxy, what these patent statistics suggests is not that the publicly funded programs lost their importance but, rather, that they lag behind in a game of commercialization that they were not destined to compete in to begin with. Statistics show that even after the

Bayh-Dole Act[170] and the establishment of technology transfer offices in all major universities, with the exception of a few elite institutions like Stanford and Columbia, licensing revenue from patents is a very small part of the total research budget.[171]

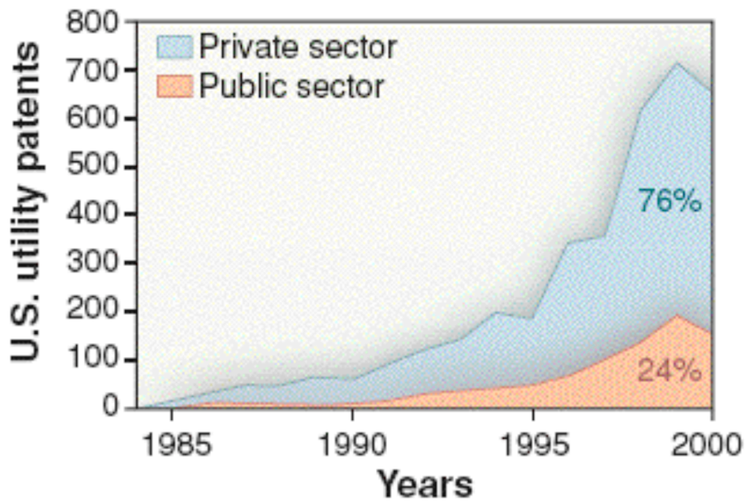

Figure 6-2: The shift in the amount of private vs. public utility agricultural patents in the United States from 1984 to 2000[172]

One reason for this is that smaller institutions find it hard to compete in such a market. In theory they can commercialize their innovation and use the funds to spur more innovation, but in actuality in a patent-rich environment they often need to license tools and methods that they would otherwise have gotten for free. Arguably, by making a few scientists in public sector institutions ultra-rich, the Bayh-Dole Act created a “jackpot” culture within the university complex, which stands in stark opposition to the common scientific ethos of sharing and distribution. For agricultural

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[170] *Bayh-Dole Act (Rights to Inventions Made by Nonprofit Organizations and Small Business Firms under Government Grants, Contracts, and Cooperative Agreements)*.
[171] Benkler, *The Wealth of Networks : How Social Production Transforms Markets and Freedom*, 340.
[172] R.C. Atkinson et al., "Intellectual Property Rights: Public Sector Collaboration for Agricultural Ip Management," *Science* 301, no. 5630 (2003): 174.

innovation of crops with low market potential, the consequences can be harrowing. A recent study found that:

> …small markets in developed countries are likely to go unserved because there are insufficient incentives to conduct research and development directed at such markets…the combination of public sector anticommons tragedy [collectively wasting resources by under-utilizing them] and private sector concentration exacerbates the neglect of agricultural research and development conducted for the benefit of poor people in developing countries. The immediate result is continued poverty and hunger for many millions of people around the world. In the longer term, this situation threatens genetic diversity, undermines effective biosafety regulation and may hinder the overall progress of science and technology in this field.[173]

PIPRA (Public Intellectual Property Resource for Agriculture) is an initiative that was started by leading American organizations, including several universities and foundations, in order to avoid these dangers. PIPRA's stated purpose is to "help public sector agricultural research institutions achieve their public missions by ensuring access to intellectual property to develop and distribute improved staple crops and improved specialty crops."[174] PIPRA aims to make agricultural technologies more easily available for development and distribution in the developed world. PIPRA shares CAMBIA's premise that agricultural innovation is incremental, and depends largely on access to and availability of relevant tools and materials (like biotechnologies and germplasm.) It also supposes that the needs of the developing world are different from that of the developed world, and that accordingly the mechanisms required for promoting agricultural innovation in the developing world are different. Unlike CAMBIA, which is a company and which deals with IPR as part

[173] Hope, "Open Source Biotechnology", 55.
[174] *Pipra Homepage* [Web] (Public Intellectual Property Resource for Agriculture, 2006 [cited 08/16 2006]); available from http://www.pipra.org.

of a larger activity, PIPRA is an alliance of public organizations, and is focused solely on IPR in the public sector.

Fourteen university presidents and institution chancellors partnered to found PIPRA, and they published an article in *Science* in order to bring agricultural IPR to center stage. The following excerpt summarizes their position:

> Dating back to the establishment of the Land Grant College system in 1862, universities and other public-sector institutions have been the leaders in developing improved crop varieties that were transferred to farms and to the agricultural industry through cooperative extension services in the United States or equivalent organizations internationally. However, this model is changing rapidly because of increased intellectual property (IP) protection of agricultural inventions, as well as the development of a research-intensive private sector that is making notable contributions to enhancing the productivity of U.S. agriculture. The private sector logically focuses on crops such as corn and soybeans where markets are large [aka “cash crops”], which leaves the development of small specialty crops for the United States and subsistence crops important to the developing world mostly in the hands of the public sector. In the past 25 years, fundamental changes in the nature and ownership of innovations in basic and applied agricultural research have complicated the mission of our public research institutions. As the importance of biotechnology in biological research increased, the possibility of patenting and licensing biotechnology expanded through changes in the legal and policy framework. The Supreme Court decided in 1980, in Diamond vs. Chakrabarty, that living, human-made microorganisms can be patented. Also in 1980, the Bayh-Dole Act was passed to encourage U.S. universities to patent their innovations and to license them to private-sector companies in order to encourage their commercial use. Since that time, formal mechanisms for transfer of public research results to the private sector for further development have accelerated, and there has been a marked increase in the number of public-sector patents and the licensing of technology to the private sector. Agricultural technologies pose a particular challenge for university technology transfer programs in balancing the objectives of technology commercialization with humanitarian purposes or for applications to specialty crops.[175]

[175] Atkinson et al., "Intellectual Property Rights: Public Sector Collaboration for Agricultural Ip Management."

In summary, PIPRA members believe that the public sector remains an important source of innovation in agricultural research, despite the sector's growing commercialization, especially when it comes to subsistence crops in which the commercial market, almost by definition, finds no interest. PIPRA and CAMBIA share the desire to create a common pool of technologies that will be available for developing countries and the goal of simplifying licensing practices, but their strategy is different.[176] CAMBIA is focused on creating a pool of technologies, focusing on 'code'. PIPRA hopes to change things from the inside, focusing on 'norms'. In my interviews and discussions with CAMBIA's employees who had experience working with academic institutions, many were skeptical about the possibility of making real change from inside the university complex. Several interviewees described how academic programs are too susceptible to external commercial interests, if not outright corrupt. For the right price, academic programs might sell out. A vivid example of this possibility is given in a recent case in which after a long patent dispute the University of California whose president Atkinson was first author on the PIPRA *Science* publication, has agreed to grant Monsanto an exclusive license to its patent-protected Bovine Growth Hormone technology for a staggering $100 million.[177] CAMBIA was trying to avoid this possibility by offering a comprehensive framework that would align the interests of commercial and publicly-funded centers while guaranteeing, using the BIOS license family, that the results of the research remain open and sharable.

[176] Ibid.: 175.
[177] MC Interview. See Trey Davis, *Press Release: Uc, Monsanto Reach $100 Million Settlement in Growth Hormone Patent Case* [Web] (University of California, February 28th 2006 [cited October 28th 2006]); available from http://www.universityofcalifornia.edu/news/2006/feb27b.html.

The CGIAR and International Agricultural Research

The Consultative Group on International Agricultural Research (CGIAR) network represents the next relevant social group, international research centers that are independent of the university complex. CGIAR is a U.N. and World-Bank backed strategic alliance of countries, international and regional organizations, and private foundations like Rockefeller supporting fifteen international agricultural centers. The CGIAR grew out of the initial international response to widespread concern in the 1950s, and 1960s, that many developing countries would succumb to famine.[178] With a proclaimed objective to "mobilize agricultural science to reduce poverty, foster human well-being, promote agricultural growth and protect the environment",[179] in its 35 years of operation the CGIAR played a prominent role in fighting hunger by helping increase crop yields, which in some areas more than doubled.[180]

In recent years, CGIAR institutions have been struggling with agricultural innovation in the face of increasingly complex IPR landscapes and the increasing disparity between the developed and developing worlds.[181] Several CGIAR research centers have been looking for solutions to the problems of IPR, and of particular

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[178] For a fully history see *The Origins of the Cgiar* (Consultative Group on International Agricultural Research, 2004 [cited 08/16 2006]); available from http://www.cgiar.org/who/history/origins.html.
[179] *History of the Cgiar* (Consultative Group on International Agricultural Research, 2004 [cited 08/16 2006]); available from http://www.cgiar.org/who/history/index.html.
[180] A detailed and updated discussion and summary of the CGIAR approach to food security is available in Joachim von Braun, "The World Food Situation: An Overview" (paper presented at the CGIAR Annual General Meeting, Marrakech, Morocco, December 6 2005).
[181] A recent survey that was conducted in 105 CGIAR-related research centers in 33 developing countries found that researchers are concerned that pressures to commercialize part of their research may force them to change research priorities at the expense of projects targeted on small-scale farmers or on marginal areas that have smaller commercial prospects. See David Bigman, "Intellectual Property Rights and the Commercialization of Public Agricultural Research in Developing Countries," in *Globalization and the Developing Countries: Emerging Strategies for Rural Development and Poverty Alleviation*, ed. David Bigman (Oxford, UK: CABI Publishing, 2002), 192. A second study on public sector national agricultural research organizations in developing countries suggests that all these changes might be too much for the scientists to deal with. See Joel I. Cohen et al., "Managing Intellectual Property and Proprietary Technology in Agricultural Research," in *Globalization and the Developing Countries: Emerging Strategies for Rural Development and Poverty Alleviation*, ed. David Bigman (Oxford, UK: CABI Publishing, 2002), 233.

interest to us is International Rice Research Institute (IRRI). Based in the Philippines, for several decades the IRRI has been a cornerstone of the CGIAR, focusing on improving rice varieties and distributing them around the developing world with great success. One of IRRI's latest initiatives, announced in December 2005, is a joint project with CAMBIA titled the "Open-Source Biotechnology Alliance for Rice Research".[182] The IRRI, which from CAMBIA's perspective is the prime audience for the BIOS initiative, hopes to use BiOS's framework to advance the state of rice research. Robert Zeigler, IRRI's director explains the motivation for the project: "New technologies are increasingly tangled in complex webs of patents and other legal rights and are usually tailored for wealthy countries and well-heeled scientists…Half the world depends on rice as a staple food – but this also means half the world's potential innovators could be brought to bear on the challenges of rice production, given the right toolkits – and the rights to use them."[183] In other words, the IRRI sees in biological open source a stone that could kill two birds: it can help simplify legal complexities and it can help bring to bear the innovative capacity of developing world scientists. The second aim is based on an understanding that agricultural change is a complex process with many relevant social groups. A recent CGIAR study stresses that "agricultural change is not the outcome of a linear process of knowledge creation, transfer, and use. It is more often the result of interaction amongst complementary stake-holders."[184] This understanding sits well with BiOS's objectives, the tools it provides and the legal framework that it offers. The alliance is the first example of a large research center adopting the BIOS model. It is too early to assess the success of this initiative. Interviews with IRRI staff reveal that in parallel to its collaboration with

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[182] *Open-Source Biotechnology Alliance for Rice Research* [Press Relase] (International Rice Research Institute, December 13 2005 [cited 08/15 2006]).
[183] Ibid.([cited 12/04/08]).
[184] *Isnar Road Map 2002 - 2006* [Web] (International Service for National Agricultural Research (ISNAR), March 2004 [cited 08/15 2006]).

CAMBIA the IRRI has been pursuing its own ideas about open agricultural innovation in all three of its activity areas: software development, germplasm distribution, and technical innovation pertaining to rice machinery. Particularly, in early 2005, IRRI set up its own collaborative software development system similar to SourceForge called CropForge, which is a collaborative software development site providing tools and a centralized workspace for developers to control and manage software development projects relating to crop improvement.[185] As of late 2006 CropForge hosted 63 collaborative software projects in areas varying from bio-informatics to data management and had over 120 registered users. Reportedly, the majority of registered users on this system are not IRRI employees, suggesting that the project is gaining traction with its target audience of international rice breeders. Are these numbers significant? Can rice research infrastructure be developed collaboratively? One interviewee ascertained that "It is a rather slow process, technically as well as politically within the organization. But that is ok, considering that it is a paradigm shift, from control to collaboration."[186] In addition to CropForge IRRI set up a collaborative content development system called CropWiki,[187] and is contemplating the appropriate license for it.

IRRI has a collection of over 100,000 seed samples, mainly of local varieties, in a cold store. It distributes this germplasm under its own version of an open Material Transfer Agreement (MTA) that prevents recipients from claiming IPR on the germplasm and requires granting others the same rights if the germplasm is passed on.[188] As one interviewee explains users can "eat it, grow it, farm it, sell it, give it

[185] *Cropforge Homepage* [Web] (International Rice Research Institute, 2006 [cited October 28th 2006]); available from http://www.cropforge.org.
[186] TM Interview
[187] *Cropwiki Homepage* [Web] (International Rice Research Institute, 2006 [cited October 28th 2006]); available from http://cropwiki.irri.org/icis.
[188] *Irri Interim Mta* [Web] (International Rice Research Institute, 2006 [cited October 28th 2006]); available from http://www.irri.org/grc/requests/InterimMTA_English.pdf.

away, sell progeny, use it for research, use it to derive improved varieties, even claim IPR on the derived varieties. They just can't claim it as their own."[189]

In addition, IRRI helps spread technical innovation in an open way. IRRI engineers come up with principles and "concept prototypes" or "industrial prototypes", often in collaboration with National Agriculture Research Institutions, manufacturers and users. The model is based on supplying anybody who is interested with the drawings and specifications, encouraging manufacturers to produce the products and make local adaptations usually based on the needs of the users. As one IRRI researcher recalls "often the machines/technologies sold to farmers are based on IRRI design but modified in size, capacity, adapted to locally available materials and to local market needs."

In summary the CGIAR system, which is based on public funding for agricultural research, is open to the BIOS idea. As one interviewee put it, is "the business of producing Global Public Goods, non-exclusionary and non-rivalrous" is the main logic behind the CGIAR.[190] Like any other institution, however, the CGIARs have their own history, protocols, licenses, processes, etc. For an organization with such a long history and particularly one that is backed by international bodies like the U.N., which rely on consensus for decision-making, shifting their existing practices into the frame of biological open source will be a long process if not everlasting. The IRRI example will be one to watch.

The Rockefeller Foundation

The funding agencies, particularly the Rockefeller Foundation, which had been CAMBIA's primary funder since its inception, also have an important role in this story. When Gary Toenniessen first hired Jefferson and sent him around the

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[189] Sackville Hamilton, Ruaraidh excerpt in TM Interview
[190] TM Interview

developing world, he had no idea that the assignment would turn into a two-decade symbiotic relationship. As he explains in an interview: "Richard [Jefferson] has had funding from us continuously for one thing or another since he went off to Australia, and in return we have used Richard." [191] This relaxed approach to the use of funds beyond their original purpose can be explained by looking at the role that Rockefeller sees itself playing in this game. As Rockefeller officers have told me in interviews, they perceive their agency's funding as the driver for revolutions of the greatest magnitude in agriculture. A recent Rockefeller handout, for example, emphasizes the idea that "before all else, the original Green Revolution was a product of philanthropy, in a carefully negotiated partnership with government."[192] In other words agricultural innovation on this view is not primarily about the science; given enough money and the partnerships that it can foster, the science will follow. In an interview, a Rockefeller program officer suggested that with its strategically awarded grants Rockefeller has been behind the rise of the entire field of molecular biology. As evidence to this claim he quoted statistics that show that at some points during the 1990s Rockefeller had more molecular biologists on its payroll than any other research organization.[193] Even discounting such self-legitimating claims, the role that Rockefeller played in the field is clearly significant. Lily Kay has documented how Rockefeller had been a significant actor since the 1930s. She argues that, "[since 1932] the Rockefeller Foundation was in a strong position to shape fields in the life science that fell outside the scientific domain of the federal government."[194]

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[191] Poynder, *Biological Open Source: Interview with Richard Jefferson, Founder and Ceo of Cambia, and Leading Light of the Biological Open Source Movement* ([cited 12/04/08]).
[192] "Africa's Turn: A New Green Revolution for the 21st Century," (New York: The Rockefeller Foundation, 2006).
[193] JW interview.
[194] Lily E. Kay, *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology* (New York: Oxford University Press, 1993). See also Robert E. Kohler, "Warren Weaver and the Rockefeller Foundation Program in Molecular Biology, a Case Study in the Management of

When I asked him about the foundation's ongoing support for BIOS, the program officers described the problem of agricultural innovation as "not optimized towards the betterment of human life because market forces drive it exclusively."[195] Funding to CAMBIA can be seen as an attempt to find a better balance, to give a chance to an alternative model that would not be exclusively market-driven but also community-oriented, and thus will be more beneficial to the developing world. In supporting BiOS, Rockefeller is trying to replicate what they perceive as the great success of the Green Revolution. The goal of their food security program is to "improve the lives of the rural poor through the generation of agricultural technologies, and support for institutions and policies that improve food security."[196] Supporting CAMBIA falls under the categories of both technological innovation and institution building. Even if only some of what BIOS is promising will work—say, apomixes or sentinel plants—Rockefeller expects it will see a tremendous return on its investment. So far they have been convinced each year that there is sufficient progress to warrant more funding. They are still waiting for the big breakthrough and for massive adoption, which might never come.

The Biotech Industries

As described above, market forces have been the predominant forces in agricultural innovation in the last several decades. Market and industry actors include the multinational firms that Peter Drahos has dubbed "biogopolies,"[197] as well as small start-up companies, which are trying to conquer niche markets. Companies across this spectrum, large or small, are all involved in for-profit research and for most of them

Science," in *The Sciences in the American Context, New Perspectives*, ed. Nathan Reingold (Washington DC: Smithsonian Institution Press, 1979).

[195] JW interview.

[196] *Rockefeller Foundation Food Security Program Policy* [Web] (Rockefeller Foundation, 2006 [cited October 31st 2006]); available from http://www.rockfound.org/Grantmaking/Agriculture.

[197] Drahos and Braithwaite, *Information Feudalism: Who Owns the Knowledge Economy?* , Ch 10.

biological open source represents a threat to thriving businesses. The BIOS model is alienating to most of these companies since in most cases it would require them to change their business models, which rely on the propertization of agricultural innovation and its protection with strong IPR. Distributing the tools for agricultural innovation more equitably is a form of long-term thinking that is hard to sell in this context. As one scholar explains: "The knowledge game is like playing a lottery…convincing people to move to open models is like convincing someone to put their money in the bank instead of buying a lottery ticket."[198] But the situation is even more complex since the companies at the top of the food chain have found a way to print their own winning lottery tickets by doing two things: (1) vertically integrating their businesses and ensuring control over key technologies; and (2) creating the legal landscape that would maximize the value of their property. Companies like Monsanto or Syngenta own so much intellectual property around agricultural products and processes that joining any BiOS-like arrangement would mean that they have to give up some of their rights, an idea that is diametrically opposed to their strategy. As I showed in the story of GoldenRice, under some conditions large for-profit firms are willing to grant free licenses to their innovations, but only under strict terms, such as those defined by humanitarian licenses that ensure that there will be no competition from the licensees.

We have seen in Chapter 3 that in the software sector there are situations in which sharing innovation in the open source model makes strict economic sense. Such, for example, was the case of IBM's embrace of Linux. Are there parallels with BiOS? Who are the IBMs of the biotechnological world? At this point there are none. Unlike in the computer industry where hardware and service sales have driven

[198] JH interview.

companies to embrace open source, the Monsantos of the world are not as likely to adopt the BIOS framework anytime soon. From their perspective they have nothing to gain. The proprietary game had served them well, the level of IPR protections is on the rise, and where there is a need to make special considerations, humanitarian licenses can be granted. Why should they share? From their perspective the appropriate model for agricultural innovation is served best by the proprietary, private, for-profit frame. These companies see the data concerning the scope of private patents as a testament to the proper operation of the system: private companies are pouring significant amounts of money into producing public goods in the form of improved crops. Along the way it is only appropriate that they return their investment and BIOS offers little to sustain their thriving businesses.

Some commentators have suggested that there are plenty of start-up companies for whom BIOS can be a ticket to independence from the 'gene' giants.[199] But at the same time, at the other end of the market spectrum other barriers exist. In principle, for small companies the pooling of resources makes economic sense because they can focus on their differentiators and not worry about developing infrastructure that does not confer a business advantage. The problem with this theory is that it succumbs to the classic problem of collective action. For enough small actors to partner, someone has to show that they will be getting back at least as much as they are putting in; at this early stage, this has not yet happened. As one interviewee who works for a start-up firm that had been considering BIOS puts it:

> If a company has only one type of soup, it wouldn't want to share it. If a company has multiple pots, it might be willing to open one of them. My sense is that this is too early for this to happen. There are not enough connections. You can compare this with the situation of the early railroad days: initially there was no reason for monopolies to

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[199] Aileen Constans, "Tools and Technology Open-Source Initiative Circumvents Biotech Patents," *The Scientists* 19, no. 8 (2005).

> share their tracks, but as more tracks developed, incentives for sharing developed…Biology is dominated by people in positions of power. They interact and use internal channels to get access to information and materials and thus innovate. That's how they drive the field, but the power people have no interest in diverting the channel into a more impersonal system that BIOS represents. The people who are lower down don't have the power or information needed. But it will happen over time, it may take a lot of time, perhaps 10 years. It may take many people working in their garages. A good comparison is to compare biology to hardware rather than software. Biology is in the 'hardware' phase of development. It will take time for the 'hardware' to be developed.[200]

So who uses BIOS in the industry? At this early stage it is mainly companies from the middle of the food chain from both the developed and the developing world. One of the first signatories on the BIOS license, for example, is BASF AG. BASF "is a major supplier of agricultural products and chemicals to the farming, food processing, pharmaceuticals, animal and human nutrition, and personal care industries."[201] Overall BASF employs close to 100,000 people in dozens of countries, and their 2005 sales were over US $40,000,000,[202] but in the agricultural sector BASF is not at the top of the food chain. What this means is that absent proper cross-license deals BASF is excluded from technologies like Agrobacterium, which are essential for modern plant biotechnology. Gaining such licenses is expensive, so BASF has been looking favorably at BIOS as an alternative. In a little-publicized deal, BASF recently signed a commercial support agreement with BiOS, which means that in exchange for US $150,000 they will get easy access to BioForge products, and if they choose to use them they will be bound by the terms of the BIOS license that allows them to commercialize and get IPR protections for resulting improved crops, but that limits their ability to improve on the base technologies. So far BASF has not contributed any

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[200] HZ Interview.
[201] *Basf: About Us* [Web] (BASF AG, 2006 [cited October 31st 2006]); available from http://corporate.basf.com/en/ueberuns/?id=0qUnH9U9Sbcp-ot.
[202] Ibid.([cited 12/04/08]).

significant technology back to BioForge, and has not even publicized the relationship, but the importance of this deal is that it is an early sign that large corporations could find the new technological frame useful.

A second company that recently signed the BIOS license is JK Agri-Genetics. Also known as JK Seeds, JK Agri-Genetics is a private company concentrating on research and development, production, processing and marketing of hybrid seeds.[203] JK Agrigenetics represents a group of companies within the nascent biotech industries of developing countries for whom the motivation of adopting BIOS is different from public research institutes like IRRI, although the economic rationale is similar. For this group BIOS indeed offers a ticket out of the chokehold of the IPR regimes of the developed countries as those are expressed through the gripping arm of multinational giants. A senior JK scientist explains in an interview:

> Incorporating BIOS material in our research gave us complete relief from the IP issues related to Ti-plasmids and Agrobacterium strains. We have also signed an agreement with CAMBIA to implement Patent Lens in India. We are committed to play a critical role in facilitating the services of Patent Lens to the Indian scientific community. We are currently studying the possibilities of exploiting the benefits of the amazing technology, DArT in our crop improvement programme through molecular breeding… enjoying the fruits of scientific advancement have [sic] been a dream for the people living in the developing countries. The wealth of the developing countries is being moved to the developed countries with existing concepts of IP rights. The open models of the IP concepts are of a great advantage to the developing countries to combat the technology monopoly from developed countries…[204]

This collaboration might as well be the poster child of the BIOS initiative. It represents CAMBIA's hope that BIOS will help bring out the innovative capacity latent in developing nations. Such collaborations will become particularly important in

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[203] *Jk Seeds Homepage* [Web] (2006 [cited November 8th 2006]); available from http://jkseeds.net/.
[204] PSB Interview

the upcoming years when countries like India are expected to bring into full enforcement the regulations set forth by the TRIPS agreement that calls for IPR harmonization across the WTO member states.[205]

In summary, unlike in software where the open source framework makes economic sense to profit-maximizers both large and small, in biology it is most likely that the adoption curve will start with medium size companies. As one interviewee told me:

> In biology people distinguish between tools and products. If the BIOS concept is successful the value of tools would drop and the incentives to share the tools would increase. Organizations will distinguish themselves by the products. Things will change soon. For example, the ability to synthesize and genetically modify organisms will become trivial. Just like hardware became taken for granted, and the design of the software became the issue. We're in the incredible focus to find methods for gene manipulation but once the methods are cracked, the focus will be on genetic design, the good genetic designs will rule.[206]

I will come back to this discussion in the section below on 'core vs. context'.

Discussion: BIOS, the GMO debate, and other dangers

The data I presented above shows that as agricultural knowledge became increasingly technology-oriented, it became increasingly subject to controversial proprietary protections. To a large extent it also became concentrated by a handful of private interests. I read both of these changes as changes in an information economy that have profound implications for democratic culture in an information society, i.e. for the ability of citizens to control the information that is meaningful to their life. To a large degree the alternative that BIOS and the related social groups propose revolves

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[205] For a discussion on India's approach to TRIPS implementation see: Jason Pielemeier, "The Role of Treaties in Intellectual Property," in *Access to Knowledge*, ed. J. M. Balkin and Y. Benkler (New Haven, CT: Yale University Press, forthcoming).
[206] HZ Interview.

around the capacity to dissolve these knowledge concentrations using norms, laws, markets and code.

I have argued elsewhere how the existing knowledge game results in the international food distribution system failing to distribute the global calories output adequately, thus creating persistent food insecurity.[207] I will not repeat this argument here; rather, I want to investigate the key differences between the traditional models and the BIOS model, namely the attitude towards the GMO debate. The visions painted around GMOs vary widely and range from dystopias that predict the worst types of ecological disasters to utopias that forecast cheap and accessible food for the world's hungriest. There is no disagreement that GMO food production is increasing, and that it may have a direct influence on the food security problem. Proponents, like Norman Borlaug, think that GMOs are the only way to keep up the increase in production levels that can meet the rise in global population and the billions of hungry mouths that will likely be added to the globe in the upcoming decades.[208] Opponents think that the dangers outweigh the benefits. The gap between these two approaches is deep and hard to overcome. Each group brings a different understanding of biology, chemistry, ecology, human health as well as risk management, economics, and ethics. As Javier Lezaum finds, the key objections to GM technology arise out of different sets of concerns that include ecological and environmental concerns, health concerns and regulatory and economic concerns. These concerns figure strongly in the changing attitudes towards GMO regulations.[209] Clearly, a system that reduces access barriers to technologies that enable genetic engineering exacerbate these fears as they potentially increase ecological, environmental and health risks. To this extent BIOS and other

[207] David, "Peer-Production for Development: The Case of Agri-Biotech."
[208] *Biotechnology and the Green Revolution: Interview with Norman Borlaug* ([cited 12/04/08]).
[209] For a detailed analysis of how regulatory attitudes changed over the last several years see Lezaun, "Creating a New Object of Government: Making Genetically Modified Organisms Traceable."

attempts to increase access to biological innovation are threatening to critics of GMO who believe that reducing the barriers to molecular biology in general and genetic engineering particularly, means that smaller institutions and individuals could practice a potentially risky science while lacking the social responsibility or economic ability to monitor their own operations. There is little that can be offered that would alleviate these legitimate fears, however, one of the first things to note is that these fears revolve around risk and the perception of risk and that these depend directly on one's model of the information economy. Risk can be mitigated by both the market (insurance, penalties, compensation) and the law (government regulations, self-imposed regulation).

When it comes to economic concerns, however, the two sides of the debate blur. A recent study by the Royal Society found two types of economic reservations about GMOs: (1) a worry that multinational corporations will use their power to avoid regulation; and (2) a worry that with the rise of GMO very few will reap the economic benefits and that the farmers and consumers will be worse off economically.[210] These worries arise out of the trends I explored above, namely, the commercialization and proprietarization of agriculture, which has been exacerbated by the introduction of more advanced technologies. Over the last decade, the agribusiness sector is morphing into a global agribiotech sector. Since the mid 1990s this sector has been awash in a tsunami of mergers and acquisitions leaving only the multi-billion dollar 'Gene Giants' to stand dry.[211] Statistics show, for example, that in 2003 Monsanto alone (including all the subsidiaries that it acquired) produced seeds for more than 90% of

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[210] A detailed mapping of common attitudes is given in "Genetically Modified Plants for Food Use and Human Health—an Update Policy Document 4/02, 2002," (London, UK: The Royal Society, 2002).
[211] Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology*, 297.

the GM crops worldwide. Another four companies: Syngenta, Bayer Cropscience, Dow and Du Pont produced the rest.[212]

Arguably, in this lopsided concentration lies the heart of economic concerns about GMO. Evidently, most biotechnology developments are controlled by a handful of private interests that use IPR regimes to control the future of food production. Under these extraordinary concentration conditions, the GMO debate soon leaves the realm of science and enters the political-economic arena where even the most 'objective' finding is apparently tainted by political or economic bias. Moreover, under these conditions it is hard to separate the wheat of real claims against GMO from the chaff of over-romantic perceptions of past eras and yearnings towards organic alternatives to agricultural production. There is no doubt that the risks concerning GMO need further investigation, but the question remains: what are the appropriate frameworks for exploring these risks while giving a chance for innovation and potential benefits to be experimented with, given the acute food insecurity problem. CAMBIA believes that participatory and open frameworks might allow such experimentation without the associated fears. Jefferson argues that the GMO debate can wither away altogether when he says:

> Linux doesn't have viruses because it is 'ours'. Everybody likes to buy his or her croissants in a small bakery…but people can't bear large capital. The GMO debate is not about scientists teaching people…at BIOS we don't consider ourselves as scholars but as practitioners. We have to educate the people, showing that biotechnology in and of itself is not good or evil. We want to galvanize informatics to be able to map mind fields and not only green fields.[213]

It is too early to tell how convincing this argument is. BIOS is currently below the radar of GMO watchdog organizations who focus their attention on the gene

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[212] Ian Sample, "Gm Crops," *The Guardian*, Tuesday June 3, 2003.
[213] Jefferson Interview.

giants. As in several other aspects of this story, only time will tell what the upside is; clearly there is a potential downside too. An immediate danger in opening up biological innovation and reducing barriers to related innovation is that of increasing the risk associated with malicious use of the technology, primarily by would-be terrorist groups. What if a rogue group decides to use the BIOS toolkit not in order to increase protein levels or pest resistance but rather in order to turn food crops poisonous or to manufacture lethal pathogens? Jefferson thinks it makes no significant difference. "Bin laden is not sitting in his cave worried about Monsanto's patents," he jokes "and besides, there are so many naturally occurring pathogens like natural Anthrax, that nobody needs to invent new ones."[214] Or as another interviewee put it:

> People often raise the issue of security. I think that's a red herring. The concern that terrorists get access to dangerous technologies has always been a threat. The response is having as many people be able to respond. Doing things in an open way doesn't mean ignoring containment and security. The same goes for GMOs: openness would enlarge the small group of people who can watch them. Open source promotes both biosafety and biosecurity.[215]

In sum, according to this line of argument, evildoers who have the political will to use biotechnologies adversely already have the means to do it and will not benefit too greatly from the new improvements, which are mainly legal and economic, not technological. On the other hand, the biological parallel of the 'many eyes spot many bugs' adage, which I presented in Chapter 3, suggests that wide adoption, decentralization and sharing are the solution, not the problem. From a democratic culture perspective, favoring a system that is participatory is clear.

A third danger has to do with liability issues. Common wisdom suggests that when a firm or a reputable NGO stands behind a technology, the tort system

[214] Jefferson Interview.
[215] JH interview

guarantees at least minimum attention to quality control for the fear of liability claims, which can be filed in case of negligence. Who will guarantee quality and safety when behind a new plant variety stands a whole community of researchers that collaborated in multiple stages and at disparate geographical locations, rather than a single entity? Who will take the blame if a plant variety that was developed using biological open source is lethal or have negative environmental impact? Moreover, in FOSS the open source licenses often stipulate that the product comes 'as is' with no guarantee or warranty expressed or implied. Is such a low standard for food-related products in which errors could be fatal acceptable? There are no easy answers yet to these important questions since these situations are hypothetical. The regulatory entities, legislators, and the courts have not yet addressed the issue, simply because it is too early. There is however a difference in philosophy here. From the BIOS perspective these questions in and of themselves are misguided. While it is true that there might be legal ambiguity concerning liability claims, under the biological open source model overall accountability is enhanced, not reduced. The many eyes that are watching the many hands that participate in the open innovation process make it more likely that errors and pitfalls will be exposed earlier rather than later. Over time it is expected that both legal and market mechanisms would develop to solve this challenge. In the software arena instruments like an open-source developers insurance are emerging[216] and commercial companies are starting to offer maintenance and service agreements to support open source development efforts. It is possible that parallels would develop in biology as well.

So what does all this mean for democratic culture? I analyze this along several dimensions. First, I want to argue that BIOS enhances the creation and maintenance of

[216] *Open Source Compliance Insurance* [Web] (OS Risk Managment Ltd., 2006 [cited November 8th 2006]); available from http://www.osriskmanagement.com/open-source-compliance-insurance.shtml.

a healthy knowledge commons, which is an essential element in a just information society. Unlike the existing trends in the sector, which favor propertization and enclosure and require market transactions when knowledge sharing is needed, BIOS promotes the pooling of resources together in publicly available databases, which are open to all members and easy to navigate. Knowledge from the database is licensable under simple terms and includes not only know-how but also concrete products like plant transformation vectors and marker genes.

Second, BIOS enhances democratic culture by increasing the global flow of information as it allows actors with diverse motivations to participate and work towards a shared goal. Both CAMBIA and PIPRA enable research centers, universities, not-for-profit organizations and private actors to collaborate without having to agree on a grand goal or a long-term plan. Surprisingly perhaps, the strength of these collaborations comes from their simplicity. The principle of self-selection and assignment of tasks is at play. Nobody directs the research from above. Each participant chooses what projects to work on, and to what extent. This stands in stark contrast to market strategies or hierarchies that are based on price signaling or managerial commands to decide what gets done and when, and treats knowledge as a source of wealth.

Third, BIOS represents an efficient non-market mechanism for public resource allocation. Most of the participant organizations in BIOS as well as the members of PIPRA are publicly-funded research centers whose main motivation for innovation is not (or not primarily) financial. Member organizations can collaborate on given projects without expending valuable resources on costly technology-transfer and cross-licensing arrangements as they would in a market-based system. Based on publicly available and easily obtainable data, members can self select their research contribution, knowing best what their strengths and weaknesses are, and what their peers are working on, thus selecting more effectively. The same is true for BiOS's licensees.

Lastly BIOS enhances democratic culture by fostering a 'solution stack' that facilitates not only access to end products but also to the tools that enable further development of knowledge embedded goods. In computing, "a solution stack is a set of software subsystems or components needed to deliver a fully functional solution…for example, to develop a web application, the designer needs to use an operating system, web server, database and programming language."[217] In the case of FOSS the stack is built by operating systems like Linux, web-servers like Apache, programming languages like PHP or PERL, and databases like MySQL. In the case of biology no clear definition of the solution stack exists, though one can think of the most basic layer, the operating system, as traditional methods for domestication of plants. Higher levels on the stack will be databases of genetic material, tools to allow manipulation of those databases, and techniques for applying those tools in local contexts.[218] Originally these processes were very open and were based on the ability to use and modify. In the last several decades, As I showed, the shifts around agricultural innovation closed up this process. Choking the stack at a basic level hinders innovation at a higher level. The solution is to free up the stack, to supply the necessary elements at each stage so that innovation at the next phase could take place. Move up the stack is tantamount to moving from core to context. At the core, the bottom of the stack, are generalized tools and technologies. At the top, the context, are specific applications that make use of the basic tools and techniques. This distinction is, of course, valid for both closed and open systems. In closed systems, the

[217] Wikipedia: "Solution Stack"
[218] R. A. Jefferson, "Comments on Agriculture and Genetically Modified Foods and Access to Knowledge" (paper presented at the Access to Knowledge, New Haven, CT, April 23rd 2006).

connection among the levels of the stack is done using protocols and standards. In software, for example, those standards often take the form of Application Programming Interfaces that allows further innovation on top of a closed system (Microsoft's Windows™, for example, has thousands such interfaces that allow third party developers to develop applications without ever seeing the code of Windows™). For ensuring ongoing participation, an emphasis is needed on ongoing assurance of access and ability to use all levels of the stack. In the eyes of Jefferson and his staff, the different BIOS projects and initiatives I explored above are trying to do just that.

Conclusion: an outlook for Biological Open Source

Many question remain open at the end of this investigation. Can biological open source ever succeed? What would it mean for it to succeed? Could it become the dominant frame for conducting agricultural innovation or will time prove that the stakes are too high and that industrial incumbents will quash any attempts to shift the paradigm from for-profit to collaborative agricultural innovation? Can the world's poor be expected to contribute to collaborative projects for which the returns might be far away?

This story does not yet have closure; clearly the meaning of biological open source has not yet stabilized. Perhaps there are some cues that the history of free and open source software can offer us. As I noted earlier, the invocation of the 'open source' metaphor and the comparisons of biology and software, which are inherent in BIOS, are a cognizant attempt to make those connections explicit. Still, there is not enough evidence at this stage to suggest answers to the above questions. As I discussed above, early evidence suggests that the barriers to participation in molecular biology might be too high for a participatory model like BIOS's to ever be fully embraced.

The outcome will depend in part on policy choices yet to be made. There is a good basis to forecast that biological open source, if and when it becomes significant, can offer an important layer that can, at the minimum, augment the existing agricultural innovation system and help, at least in some part, alleviate the food security problem by releasing to the people who need it most foundational technologies. At the same time, the opening up of the biological innovation process to more participants presents risks that are hard to evaluate, primarily around the concept of GMO and genetic engineering. As I discussed, some critics prefer more regulation, not less, and to them the prospect of lowering barriers of participation and reducing regulatory regime seems dangerous.

This case study, the last in my work, contributes to my overall argument in two ways. First, it demonstrates that the notion of participatory information networks today extends beyond software or communication. As I have argued, agriculture today is directly influenced by, on one hand, advances in biotechnology, and on the other hand, the constant expansion of IPR. Within this context, BIOS offers direct historical continuities to FOSS from which it takes inspiration. As a system that is open to volunteer participation, BIOS tries to replicate FOSS's legal, social, and technical structures. As I have showed, to date this is done with limited success. In addition, as the most recent case of the four cases I studied, BIOS offers a contemporary glimpse into an ongoing debate. By investigating this case while it's still 'hot' I had the chance to see up close the ways in which a new technological system is stabilizing.

Overall the case leaves me with the notion that opening a system to massive volunteer participation is not a blanket solution to any problem; it is an idea that can succeed to different degrees in different domains. Many of the connections that the actors behind BIOS are invoking between biology and software, are ideological in nature. The ideology of openness will be the subject of the next chapter.

CHAPTER 7:

EPILOGUE – OPENNESS AS AN IDEAL-TYPE AND THE IDEOLOGY OF OPENNESS

> The tension between small-scale association and large-scale organization, between personal autonomy and institutional regulation, between remote control and diffused local intervention, has now created a critical situation…From late Neolithic times in the Near East, right down to our own day, two technologies have recurrently existed side by side: one authoritarian, the other democratic, the first system-centered, immensely powerful, but inherently unstable, the other man-centered, relatively weak, but resourceful and durable. If I am right, we are now rapidly approaching a point at which, unless we radically alter our present course, our surviving democratic technics will be completely suppressed or supplanted, so that every residual autonomy will be wiped out....
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> Lewis Mumford, 1964[1]

> No idea is more provocative in controversies about technology and society than the notion that technical things have political qualities. At issue is the claim that the machines, structures, and systems of modern material culture can be accurately judged not only for their contributions to efficiency and productivity and their positive and negative environmental side effects, but also for the ways in which they can embody specific forms of power and authority.
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> Langdon Winner, 1980[2]

Introduction

Writing in *Technology and Culture* over four decades ago, cultural critic Lewis Mumford warned us with a sense of urgency against the suppression of what he perceived to be an essential aspect of democracy. At the wake of WWII and the big

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[1] Lewis Mumford, "Authoritarian and Democratic Technics," *Technology and Culture* 5, no. 1 (1964).
[2] Langdon Winner, "Do Artifacts Have Politics?," in *The Social Shaping of Technology*, ed. Donald A. MacKenzie and Judy Wajcman (London: Open University Press, 1985), 28.

science projects of the 1950s, Mumford worries about the dominance of technologies that reduce the role of humans, turning them into part of a machine. He laments the socio-technical configurations that deliberately eliminate the whole human personality, ignore historic processes, or position control over nature and humans as the chief purpose of existence. Mumford argues that this divide can be traced throughout the history of technology and urges as to consider the social and moral imperatives of our time. What we need to be asking ourselves, he writes, is "not what is good for science or technology, still less what is good for General Motors or Union Carbide or IBM or the Pentagon, but what is good for man: not machine-conditioned, system-regulated mass-man, but man in person, moving freely over every area of life."[3]

In this last chapter of my work, I want to suggest a reading of open systems that is informed by Mumford's question, suggesting that like Mumford's authoritarian and democratic technics, open and closed systems present two alternative visions for the information society that have significant bearing on the shaping of this society over time. This choice also has political implications, or as Winner puts it, according to the strong version of the theory of technological politics,

> …the adoption of a given technical system unavoidably brings with it conditions for human relationships that have a distinctive political cast–for example, centralized or de centralized, egalitarian or inegalitarian, repressive or liberating. This is ultimately what is at stake in assertions such as those of Lewis Mumford that two traditions of technology, one authoritarian, the other democratic, exist side by side in Western history…Although one can recognize a particular result produced in a particular setting, one can also easily imagine how a roughly similar device or system might have been built or situated with very much different political consequences.[4]

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[3] Mumford, "Authoritarian and Democratic Technics."
[4] Winner, "Do Artifacts Have Politics?," 33.

Clearly, configuration of information networks can influence the future of a society's politics, culture, and the roles of citizens within that culture. As I argued in the case studies, choosing between these two competing visions—or mixing them—can greatly alter the ways in which people communicate with each other, engage their friends or enemies, study, do business, participate in their culture, eat, create and even procreate. Since much is at stake, I believe that it is important to improve our understanding of encounters between openness and enclosure, which, as I will argue, can be seen as a clash between two competing ideologies. By doing so I hope to help untangle some of the complexities that must be overcome when information systems are designed, developed, and regulated.

In the previous chapters I explored continuities and discontinuities between four different open systems and the closed systems with which they contrasted. On one hand were systems like those promoted and maintained by AT&T, the army, Microsoft, or Monsanto while on the other hand were systems such as the ARRL, GOC, Linux, or BIOS. Evidently, while differences abound, the classification of these two types of systems is anything but clear-cut. As I summarize below, there are plenty of similarities as well as dissimilarities between them. This chapter, therefore, starts with an abstraction of open systems as an ideal type, showing how each of the systems explored in the case studies relates to it. Building on this definition, the chapter continues with revisiting some of the main findings from the case studies in order to explore openness as an ideology. I finish with an analysis of the risks and rewards that these systems offer, outlining directions for future research.

Open systems – ideal types vs. real-world examples

The investigation of four systems, which developed at four different historical moments, demonstrated how each had different objectives, different architecture, a different audience and composition, and yet, despite all these differences, some commonalities remain apparent. As I have shown above, when large groups of volunteers organize in order to build and participate in information systems, there are similar social structures like communities, common organizing principles, such as a carefully controlled core with greater flexibility at the nodes of the network, and other properties that recur, such as the increased role of reputation management. Based on the case studies, I can now offer a revised definition for the analytic concept of ‘open systems’, which can serve here as a construction of open systems as an ‘ideal-type’ in the sense suggested by Max Weber. Weber defined an ideal-type as “formed by the one-sided accentuation of one or more points of view and by the synthesis of a great many diffuse, discrete, more or less present and occasionally absent concrete individual phenomena, which are arranged according to those one-sidedly emphasized viewpoints into a unified analytical construct.”[5] Exploring this ideal type definition is useful, as Weber noted, primarily as a backdrop for interpreting human behavior. I use it here in order to establish a baseline from which I can generalize some of the findings in the case studies, while recognizing the limitations of such abstractions.

A good starting point for the exercise of constructing open systems as an ideal type is exploring the meanings of the word ‘open’ itself. A quick lookup in a dictionary shows that ‘open’ has dozens of meanings in English as an adjective, noun, and verb including some of the following:

1. Affording unobstructed entrance and exit; not shut or closed.
2. Affording unobstructed passage: open waters; the open countryside.
3. Affording unobstructed view; transparent

[5] Edward A. Shils and Henry A. Finch, eds., *The Methodology of the Social Sciences* (New York: Free Press, 1997), 88.

4. Having no protecting or concealing cover: an open wound; an open sports car.

5. Carried on in full view: open warfare; open family strife.

6. Not sealed or tied: an open package.

7. Accessible to all; unrestricted as to participants; participatory: an open competition.

8. Free from limitations, boundaries, or restrictions: open registration.

9. Lacking effective regulation: an open town in which gambling predominated.

10. Not legally repressed: open drug trafficking.

11. Willing to consider or deal with something: open to suggestions.

12. Available; obtainable: The job is still open.

13. Available for use: an open account; the only course open to us.

14. Ready to transact business: The store is open.

15. Characterized by lack of pretense or reserve; candid: Please be open with me.

16. Free of prejudice; receptive to new ideas and arguments:

When it comes to ICTs, the word 'open' is used, by both analysts and actors, to loosely describe features that surround democracy, intelligence, projects, content, communities, publishing, access, information, standards and innovation in ways that make use of (and potentially deplete) most of the meanings above. In a comprehensive literature survey, Joseph Reagle identifies three common themes: systems described as 'open' are based on principles of participation, collaboration and sharing, or, in other words, they can be defined as those that afford an accessible and flexible type of collaboration whose results may be widely shared.[6] I want to use Reagle's definition as the basis of mine, and expand it based on my empirical finding to also include the category of distribution (both geographic and topological). In sum, I want to define open information systems as **distributed systems that are open to volunteer participation and that afford an accessible and flexible type of collaboration whose results may be widely shared**.

It is important to stress once again that this is an analytic definition. Any real-world system will be somewhat different, and only an approximation of the ideal type. Clearly, a system can be open or closed to different degrees and may map differently on any of these dimensions. Evidently, no open system is ever fully open and no closed system is ever fully closed. Open systems are those that gravitate towards more participation, more collaboration, greater sharing and greater distribution; closed systems are those that gravitate towards the other end. But no system can ever be fully closed or open. The reason that closed systems are always somewhat open is because there is always a possibility to "route around" enclosure (an obvious example of this is the widespread phenomenon of, so called, software and media "piracy", which persistently defies attempts to close media and software using legal, technical and social tools). The reason that no open system can ever be truly closed is because in order to persist, any system—closed or open—must maintain some form of persistent identity, and for this to happen some sort of rigidity, or enclosure, is necessary otherwise chaos or anarchy (or both) would ensue (one example of how such persistency is maintained is given in the rigid open-source license regimes that I explored in Chapter 3.)

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[6] Kelty offers a historical account of the use of the terms 'open systems' see Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*, Ch. 5. Reagle offers a literature review of texts making use of the term 'open', see Reagle, "Notions of Openness".

Many contemporary ICT systems exhibit mixed characteristics, for example, the Amazon.com book review system is centrally-controlled, requires a huge upfront capital-investment, creates proprietary knowledge that is owned by Amazon, is designed to maximize the firm's profit, and yet it is open to participation by a huge community of international book reviewers that are motivated by a diverse set of motivations and which peer-produce meta-data concerning the books and other products. It is a system that is participatory and which allows sharing, but which does not rely on collaboration. A system like Amazon's is both closed and open.[7] Or consider a system like the one run by The Internet Corporation for Assigned Names and Numbers (ICANN) which is an internationally organized collaboration administered by a non-profit U.S. corporation that has responsibility for address space allocation and top-level domain name system management. ICANN oversees the distribution of unique technical identifiers used in the Internet's operations, and delegation of top-level domain names (such as .com, .org etc.)[8] These services were originally performed under U.S. Government contract by a private company, Network Solutions, but were 'democratized' to some degree after international pressure. ICANN is a private-public partnership that pursues its mission through bottom-up, consensus-based processes, however, its structure (unlike the open-source technical infrastructure that enables it) is extremely hierarchical, maintains rigid national boundaries, and is highly centralized. A system like this, again, is a system that I would characterize as both closed and open. Other examples are plentiful, but the point should be clear: the more a system relies on principles of collaboration,

[7] For a detailed discussion of this system, see David and Pinch, "Six Degrees of Reputation: The Use and Abuse of Online Review and Recommendation Systems."

[8] ICANN is responsible for coordinating the management of the technical elements of the domain name system to ensure universal resolvability so that all users of the Internet can find all valid addresses. For more details see *Icann Hompage* [Web] (ICANN, 2006 [cited 06/02 2006]); available from http://www.icann.org/.

participation, sharing and distribution, the more ‘open’ it is; the more a system relies on exclusion, proprietarization, and concentration, the more ‘closed’ it is. Between these two ends lies a whole range of options.

With this in mind, I want to think again about the four open systems that the case studies presented, focusing on the many departure points between the empirical findings and the ideal type. For example, both the ARRL and the GOC do not seem to support the notion that open systems offer a “flexible type of collaboration whose results may be widely shared.” In both cases the modes of collaboration were not very flexible. In the case of the ARRL, while the decisions to join the network and where to place a relay were based on flexible self-selection, the location and routing of the trunk lines were assigned from the top down. In the case of the GOC, the system was based on military forms of organization whose command and control skeleton reflected its dual nature with clear separation between air force commanders and volunteers. Neither of these systems focused on making the results shareable, nor did they build a repository of shareable knowledge in the same sense as Linux or BIOS. Moreover, each of these systems embodies a different approach to volunteer participation. The ideal-type open system is open to volunteer participation in the most profound sense. In theory, participation is limited only by a volunteer’s desire to invest time and resources. Clearly though, as discussed in the chapters, many barriers to participation remain for even the most open system. For example, in many ways open systems are meritocracies that exclude those who do not share certain technical or cultural know-how. (See discussion on expertise below). While prior accreditation and education matter less in open systems than in closed ones, new barriers are erected by the demand to exhibit technical prowess. An open source software developer developing improvements to source code on a SourceForge project, for example, is not automatically accepted to the trusted group of ‘committers’, those vested with the power to make their code part of the next software release. And at another level, while the ideal type definition outlines open systems as those open to volunteer participation, in the case of FOSS, about half of the contributors earn money through participation in FOSS projects,[9] putting into question the strict notion of voluntarism. Other examples abound, and I discuss them below, as part of my discussion on the ideology of openness.

Openness as an ideology

The analysis in the following sections will focus on four areas that can highlight the dynamics between openness and enclosure including: economic logic, conceptions of property, social structure, and notions of expertise. Each of these areas offers a different perspective on the negotiations taking place around law, norms, markets, and code. To frame the discussion, I suggest a reading of openness as an ideology. I aim to use this term in a limited sense. Full discussion of ideology is beyond the scope of my work and has been explained elsewhere.[10] In my discussion, therefore, I follow a relatively narrow definition, following Althusser. For Althusser, ideology represents the imaginary relationship of individuals to their real conditions of existence.[11] Unlike earlier Marxist thinking, for Althusser ideology does not "reflect" the real world but "represents" relationship between individuals and the world. To this extent, ideology does not necessarily create false consciousness for failing to reflect the world, but it does, almost by definition, misrepresent itself being a mask. We are

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[9] David, Waterman, and Arora, *Floss-Us - the Free/Libre/Open Source Software Survey for 2003* ([cited 12/04/08]).
[10] For a detailed discussion of the origin of the term ideology, and main approaches to it, see David Hawkes, *Ideology*, *The New Critical Idiom* (London ; New York: Routledge, 1996). For literary criticism on the term in connection with postmodernist theory, see Terry Eagleton, *Ideology : An Introduction* (London ; New York: Verso, 1991).
[11] Louis Althusser, *Lenin and Philosophy, and Other Essays* (New York,: Monthly Review Press, 1971), 109.

always within ideology, Althusser argues, because of our reliance on language to establish our "reality", but we do not always acknowledge it. In these terms different ideologies can be seen as different representations of our social, economic, moral, or technical order. Clearly, ideologies do not exist in the abstract; they always have material existence through actions, practices, rituals, conventional behavior, and so on.[12] The discussion threads below show how openness can be seen as a form of ideology that clashes with the preexisting market-driven social order as it attempts to shift norms, code, markets, and laws. These threads are not exhaustive, but representative of the bigger picture I am trying to weave.

Economic logic: from controlling scarcity to a reputation economy

A key question that needs to be answered when understanding ideology concerns the ways in which the reproduction of the relations of production is secured. Althusser suggests that the legal-political and ideological superstructure, which is embodied in what he calls "Ideological State Apparatuses" (ISA), controls this process.[13] Importantly, for Althusser, ISAs are not apparatuses of the state but, rather, apparatuses that reproduce the state. A family, for example, can be an ISA. On those terms, we can ask what are the ISAs of open systems?

In the systems that I have studied above (with the notable exception of the GOC), I see a transition away from the state proper, and its apparatuses; I also see a transition away from the money economy and a move towards a reputation economy. All four case studies discussed systems that are not primarily driven by money and that pose relatively low capital barriers to participation. In systems like BIOS, ARRL and Linux, the role of reputation, identity-building (whether local, national, or technical), joy of learning, and 'having fun' is increased, and the role of money is

[12] Ibid, p. 114
[13] Ibid.

decreased. In other words, the economic logic espoused by participants in the ideal-type open system challenges the existing capitalist, market-driven economic order. Particularly, there are two areas of discontinuity. First there are shifts within the market, then, as Benkler argues, there are non-market mechanisms that become dominant.

Simply put, the accumulation of reputation and social capital become drivers for action more than the prospect for monetary profit. When Linus Torvalds started posting on the Minix message board and sharing his early Linux kernel code, he didn't intend to profit from it directly. When Tuska and Maxim started distributing *QST*, they didn't think about creating a services economy around the community they were building (unlike several of their followers who did). BIOS's scientists are not developing Patent Lens in hopes of renting it to the world's patent lawyers. What all these participants are doing, though, is either building their identities as experts in their fields, establishing themselves as technical leaders, or positioning themselves as central nodes on a social network. They are accumulating social capital, which is perhaps the most important currency one can have in an open system. To this end, I suggest that they are transacting in a market not for money but for reputation. Arguably, this shift from money to reputation has significant implications that will only grow as social interactions become increasingly mediated by technology. Traditional modes of authentication, accreditation, reputation, and prior acquaintance with participants rely on the social norms of close-knit communities and the accountability of meeting face to face. Since these mechanisms usually do not apply to online environments, alternative codes for reputation management were developed in recent years, including third-party certificate authorities, ratings, stars, points, karma and other techniques to signal quality, connectedness, and reliability among other traits. These new models shift the reliance of reputation systems away from traditional social networks, educational backgrounds, and institutional affiliations, and towards the wisdom of the crowd as expressed in reputation systems.

In this way, systems like SourceForge serve as good examples of how reputation economies can look when they scale. A central location becomes not only a repository for knowledge but also a marketplace for signaling technical prowess and reputation. More importantly to the discussion here, however, SourceForge or BioForge represent an alternative ideological configuration and model for the relations of production that are not premised on money as their key organizing principle. The relationships of production are secured by solidifying reputation within the system. Hence the public recording of contribution on SourceForge or BioForge and hence the physical and symbolic recording of merit in the GOC or ARRL. All serve to signal the reputation of certain actors within the system, and to stabilize the social structure that, while participatory, is still often hierarchical. We might read these mechanisms as the parallels of Althuser's ISA. These are mechanisms that reproduce the state of affairs, stabilizing it.

The next step in understanding ideology is exploring how not only the relations of production are secured, but also how the means of production are reproduced. Moving from the market into what Benkler calls the "non-market" reveals the materialization of peer-production as an important alternative mode of production.[14] In the ideal-type peer-production system, the key driver for action is not the actors' price-signals to one another through the market, but instead a process of self-selection of tasks that overall creates an alternative set of conditions for continued production. In a price-signaling world, a proverbial computer engineer, might choose to write a program due to one of two mechanisms, either (1) a signal gained from the market

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[14] Benkler, *The Wealth of Networks : How Social Production Transforms Markets and Freedom*.

through the ebb and flow of supply and demand; (i.e. Bill writing software and selling it for a fee), or (2) a command from some managerial structure (i.e. IBM employees working on a new project because their boss told them to do it). In the non-market, a programmer might choose to contribute to an open source project not because the market is signaling that this is profitable and also not because somebody commanded them to do so. They do it simply because they can self-select to do so while satisfying one or more of a variety of motivations. Likewise, in this view hams that choose to participate in the relay network, or observers that choose to set up a GOC post, do it primarily based on their own motivation and not because they are seeking rents, getting price signals, or responding to managerial commands.[15]

Taken together the emergence of the reputation economy and peer-production suggests a bigger shift in the mechanisms of value creation in ideal-type open systems. The non-rival, non-excludable nature of information, the ease of high-fidelity replication of information and information-goods, and the relatively low capital requirements necessary for participation in the innovation cycle, all add up to a shift away from an industrial information economy of scarcity and towards a networked information economy of abundance. In the new information economy value is derived not from controlling scarcity but from the ability to filter through abundance, to adapt to local settings, and to form communities and networks around information sharing in which reputation plays a more important role than money. Value in these systems is created not because a scarce resource can be exchanged for a profit but because an abundant resource can be localized and made useful by a group. The translation of Linux to local African languages for example, creates tremendous value for people who otherwise have no access to a computer operating system in their native tongue.

[15] In Chapter 3, I showed how in the software sector this ideal characterization is being challenged by the growing commercialization of FOSS.

Or, as I have shown elsewhere, the use of publicly accessible genetic engineering techniques to improve niche crops creates tremendous value for people who are threatened by global warming and desertification and need those tools to develop better draught-resistant varieties of crops like Cassava that would otherwise be low on the list of the multinationals.[16]

Clearly, these alternative configurations for the maintenance and reproduction of the relations and means of production are in themselves ideological, and this becomes apparent when moving away from the ideal types. As I showed in all the cases, the notions that participation is unencumbered, that money doesn't play a role, that there is always the possibility of self-selection, and that the system resolves primarily around reputation, are largely imaginary. Althusser notes that the imaginary is not simply false but also a driver for behavior that actualizes to some degree the conditions it imagines. We see this clearly in the case studies. In actuality, many participants do work for money, there exist barriers to participation based on merit, and sometimes on personal connections and prior accreditation, and centralized control often plays a determining role in the basic shaping of the system. To the extent that it tries to mask those barriers, openness is not less ideological than enclosure. This is even more apparent when considering relations concerning property.

Property: non-rival, non-excludable goods

Another area where the competing ideologies clash revolves around the conceptions of property and intellectual property. Systems like ARRL, GOC, BIOS, and Linux offer multiple interpretations to the concept of property and the ways that it relates to human knowledge. Clearly, deciding what can be propertied and in what ways is a salient question for an information society. Whether living genes should

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[16] For a detailed discussion of the cash-crop vs. niche-crop impact of BIOS, see David, "Peer-Production for Development: The Case of Agri-Biotech."

enjoy IPR protections, whether software should be patentable, and who gets to use the radio spectrum, are all different manifestations of the question of property rights in information and information goods.

The actors behind systems like FOSS and BIOS reject any claims that position knowledge as the same kind of property as physical property. In one of my meetings with FSF founder Richard Stallman, for instance, the very invocation of the term "intellectual property" was a cause for rumble, which almost caused him to leave the room. At another event, when I was proposing a panel in a conference that referred to patents and copyrights collectively as 'intellectual property rights', Stallman commented to me in an email message that by accepting 'their' language I was already taking sides. To this extent, Stallman and his peers are very aware of the potential that language holds for framing ideology.

The battle about defining property is a battle about words and language as much as it is a battle about the norms, law, and code. An ideological understanding of knowledge and information perceives it as having different affordances from physical goods. Knowledge and information are non-rival and non-excludable, meaning that, for example, my making a copy of your software doesn't take away from your copy of the software in the same way that my taking a bite of your apple takes away from what you already have. My listening in to your radio broadcast does not take away from Bill's ability to listen in the same way as me getting a ride in your car excludes him from getting a hitch too.

There is now a new wave of research by both activists and scholars that offers new theoretical foundations for these alternative conceptions of property.[17] Numerous

[17] First wave reserach was primarily based on technologits' own reflections, second wave research included attention from the disciplines, trying to reconcile the phenomenon within existing theories, third wave research aims to develop theories that would respect the long lasting effects and significant contribution of open systems, see the introduction article in a special volume titled "The Third wave of research on Free, Libre and Open Source Software" Ruben van Wendel de Joode, Yuwei Lin, and Shay

scholars have written on this subject. James Boyle, for example, rejects the common wisdom of the 'romantic author' and calls for relaxing IPR maximalism and increasing fair use of information.[18] Peter Drahos explains the historical context, showing how many 19th and twentieth century technological developments were part of a global 'knowledge game' in which the ability to create pockets of proprietary knowledge, protecting them using technological and legal regimes, becomes a fundamental basis for achieving commercial advantages.[19] Drahos shows how some actors understood the knowledge game early—in part by helping write the rules—and became the dominant players in their respective industries. In the ICT industry this group includes first IBM, and later Microsoft. In the life sciences arena this group includes companies like Pfizer and Monsanto. To a large degree the knowledge game is based on the ability of these players to evangelize the concept of intellectual property and to protect it using norms, markets, law and code. In my reading, these represent an ideology of enclosure[20] that conflicts directly with the ideology of openness.

Perhaps the most vocal speaker on behalf of the ideology of openness is FSF long time supporter, GPL co-author, and now director of the Software Freedom Center, Eben Moglen. From his ideological stance, Moglen argues that the properties of knowledge combined with the ability of low-cost connectivity usher in a profound change for society. Because software is non-rival and non-excludable, Moglen suggests, it has zero marginal cost, i.e., producing the Nth copy costs (almost) zero. He writes:

David, "Rethinking Free, Libre and Open Source Software," *Knowledge, Technology & Policy* 18, no. 4 (2006).. See also Benkler, "Coase's Penguin, or Linux and the Nature of the Firm.", Benkler, *The Wealth of Networks : How Social Production Transforms Markets and Freedom*.

[18] See James Boyle, *The Second Enclosure Movement and the Construction of the Public Domain* (Duke, 2003 [cited 05/17 2006]); available from http://www.law.duke.edu/journals/66LCPBoyle, Boyle, *Shamans, Software, and Spleens : Law and the Construction of the Information Society*.

[19] Drahos and Braithwaite, *Information Feudalism: Who Owns the Knowledge Economy?* , Ch. 3.

[20] SeeBoyle, *The Second Enclosure Movement and the Construction of the Public Domain* ([cited 12/04/08]).

> [T]he digital revolution alters two aspects of political economy that have been otherwise invariant throughout human history. All software has zero marginal cost in the world of the Net, while the costs of social coordination have been so far reduced as to permit the rapid formation and dissolution of large-scale and highly diverse social groupings entirely without geographic limitation. Such fundamental change in the material circumstances of life necessarily produces equally fundamental changes in culture.[21]

Clearly, such an ideological proposition, which is also technologically determinist, is purposefully positioned in order to clash with the ideology of those playing the market-driven, proprietary knowledge game. If farmers can replicate good seeds by simply planting them in the next years' crop, if users can make zero-cost copies of a piece of software, if anybody can go on the airwaves, what would be left of proprietary claims of knowledge? A form of anarchism, Moglen suggest, on which a new technical order can be established.[22]

It is important to note that these two ideologies soon move beyond words and wage war on multiple fronts, using technical, social, and legal means. In the entertainment industry, for example, Gillespie argues that Hollywood and the big record labels have consistently tried to introduce new technological means to constrain what people can do with their property.[23] These attempts have historically failed, increasing the role of law in this battle and heightening the importance of IPR. On the worldview that recognizes the differences between physical property and intellectual property, the only logical consequence is that intellectual property should not have the same forms of protection as regular property. On the wolrdview that does not recognize these differences, the only logical consequence is that more IPR protections

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[21] Moglen, "Anarchism Triumphant: Free Software and the Death of Copyright."
[22] Ibid.
[23] Gillespie, *Wired Shut: Copyright and the Shape of Digital Culture*.

are needed in order to compensate for the losses that rights holders suffer at the hand of rebellious users.

As Lessig point out, both sides of the debate often confuse the instruments with the goals. He writes: "[IP] sets the groundwork for a richly creative society but remains subservient to the value of creativity. The current debate has this turned around. We have become so concerned with protecting the instrument that we are losing sight of the value."[24]

Supporters of openness understand that in order to secure their vision of the relations of production, the law becomes a key apparatus. In the case of the ARRL this meant repeated attempts by the amateurs to fend off radio regulation; in the case of software it has led to the copyleft licenses that use copyright law to guarantee software's freedom; in the case of BIOS this understanding translates to the family of BIOS licenses. In the cases of FOSS and BIOS it translates to the actors' attempts to create a knowledge commons, a repository of knowledge and information—be it computer programs or seed lines—which are accessible and can serve as the basis of future innovation instead of being licensed out to the highest bidder. Being ideological, however, this positioning of knowledge as a special type of property still falls under the creation of imaginary relations with the world that is not immune from the critiques that it is masking itself as such.

Social structure: the rise of communities

A third key area where I observe openness as an ideology and discontinuities when ideal-type open systems are compared to closed systems, revolves around social structures. In systems such as the ARRL, Linux, and BIOS, communities become the basic social unit, contrasted with, say, families, firms, or nations. This in turn means

[24] Lessig, *Free Culture : How Big Media Uses Technology and the Law to Lock Down Culture and Control Creativity*, 87.

that decision-making processes can become more dependent on rough consensus than on managerial decisions, and that the notion of expertise becomes more reliant on performance within the system than on traditional modes of accreditation and education.

In the FOSS conferences that I attended, I noticed something that initially surprised me although I later took it for granted. When hackers self-identified they usually did not mention their nationality first; instead they mentioned their FOSS project affiliation. While nationality is still important for identity politics, for many of the hackers I met stressing which FOSS community they belonged to was more important than pointing out where they lived or where they came from. This is an example to one of the fundamental social negotiations that goes on in these systems. In systems that are open to volunteer participation, communities can rise as a dominant social form that to some degree transcends traditional boundaries such as age, geography, nationality, company affiliation, or employment status. Both as the actors' category and an analytical term, *community* becomes important. Communities serve as the social backdrop against which participants build their identity and communities serve as the basic unit in the decision making process. As, as I argued in Chapter 3, this happens primarily through attempts to reach rough consensus. Communities can range in size from a few people to tens of thousands of people. They become the social units around which Kelty's 'recursive publics' organize.[25] In other words, the recursive public is organized in communities. Communities of volunteers negotiate norms that define who can become a member and how they can remain part of the community, or in other words, communities become essential units in the maintenance of the relations of production. Members of these communities struggle to define the

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[25] Kelty, *Two Bits: The Cultural Significance of Free Software and the Internet*, 2.

law, as in the case of the ARRL. Technical know-how is shared among members of this community, both online and off, in repeated attempts to change the ‘code’. In other words, communities take on many of the roles that in other systems are performed by other social units such as a firm.

Of course, saying that communities take on all these roles does not mean that they replace firms as a dominant social structure and does not imply that the new social organization lacks structure. As the discussion in the previous chapter showed, many of these dynamics held true for firm-based systems like IBM’s Share. At the same time, while open to participation and democratic processes, open communities have clear internal hierarchies, norms, and practices that might be as rigid as those of a firm or a military organization. As I mentioned in Chapter 3, Torvalds’s close associates became known as his ‘lieutenants’, and as I mentioned in Chapter 4, ARRL Trunk Lines were kept in order by the Trunk Line Managers. More over, in both the ARRL and Linux, merit was the primary determinant of social status, a standard that on one hand has low barriers of entry, at least to the lower levels of participation, but on the other hand can be exclusionary to surprising degrees. As discussed in Chapters 3 and 4, the community is often self aware of the tension between openness and enclosure. The jokes about the secret ‘cabal’ of Linux and of Torvalds as a benevolent dictator,[26] as well as the ARRL’s trunk line readiness exercises are a testament to this tension, and to the fact that for the people participating in these systems openness cannot completely mask itself as an ideology.

Changing notions of authority and expertise

Another important aspect to the ideology of openness has to do with the reconfigurations it offers to traditional decision-making processes and notions of

[26] Coleman, "The Social Construction of Freedom in Free and Open Source Software: Hackers, Ethics, and the Liberal Tradition", Ch. 7, p. 8.

authority and expertise. As I discussed in Chapters 4 and 5, the GOC employed children, blind people, handicapped persons, and many women and in the ARRL fifteen year-olds could easily connect with eighty year-olds. As I discussed in Chapter 3, in Linux, as in the case of Torvalds, students could participate in online debates with the leading professors from around the world. Systems such as Linux and BIOS put a premium on consensus and reputation and not on rigid hierarchies and formal methods of accreditation and granting of expertise. Likewise, the onion-like structure of participation in FOSS communities, which I discussed in Chapter 3, entails significant changes to the concept of expertise.

The dynamic between accredited or expert knowledge and informal or practice-based knowledge has been a persistent focus of science studies, with numerous applications in science policy, workplace informatics, and system design.[27] Thinking about openness as an ideology raises two questions fundamental to this line of inquiry, one primarily political the other sociological. First, what is the relationship between expertise and democratic governance in complex systems? Cadres of experts and institutions for training, certification and accreditation are among the defining features of modernity, and structure much of society's complex division of labor. Althussers' notion of ideological state apparatuses highlights the roles that experts play in maintaining state control (consider the role of teachers, doctors, professors, and generals). Yet, from the opposite point of view, claims to superior knowledge sit uncomfortably with notions of democratic accountability. Such control apparatuses operate in tension with the values of broad-based participation in decision-making processes and public discourse, and of informed consent to authority. For the analyst, this problem is fundamental and two-sided. How, on the one hand, do open systems

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[27] Harry Collins and Robert Evans, *Rethinking Expertise* (Chicago: Chicago University Press, 2007).

create legitimacy within their user communities? And how do they establish it vis-à-vis external publics?

The second question explores the social processes by which certain actors acquire "jurisdiction" over technical matters.[28] Traditionally, in the cases of highly organized professions like engineering or law, this process involves processes of recognition by and institutionalization within society, with the grant of "exclusive rights" to members, professional bodies, training and certification institutions. Professions manage knowledge—adding to it but also, crucially, regulating opportunities to acquire and exercise it, and importantly to exclude others from practicing their expertise within the regulated domain. From within the ideology of openness, communities of volunteers can be seen as demonstrating how the freer flow of information made possible by open networks like the Internet (or the ARRL before it) has the potential to erode these monopoly positions. Remember, for example, the excerpt from *Popular Mechanics* that I quoted in the beginning of Chapter 4, which saw in the ARRL a possibility for long distance communication without the aid of the government or corporations.[29] While improved access to information and the empowerment of the end-users is one side of this story, the community-based models for learning, gaining recognition and developing and exercising expert authority are the other. FOSS communities, for example, blur these positions, making distinctions between production and consumption problematic.

I want to argue that open systems such as Linux are important sites for understanding these dynamics because, increasingly, their designs have a greater meaning for democracy. The challenge here is not only the 'open source' paradigm, in

[28] Andrew Abbott, *The System of Professions: An Essay on the Division of Expert Labor* (Chicago: The University of Chicago Press, 1988).
[29] Quoted in DeSoto, *200 Meters & Down - the Story of Amateur Radio*, 40.

which large scale information production is tackled through large-scale, loosely coordinated voluntary efforts, but rather the subset of projects that embed the process of aggregation, filtering, and quality control in the system itself. These systems manage reputation, experience, and incentives for participation, directed both toward learning and applying complex bodies of knowledge. As the case studies have demonstrated, these systems mobilize large-scale participation, but also adjust to the emergent characteristics of the systems themselves, as users explore the opportunities and constraints of their environments and negotiate the boundaries of code, laws, norms, and markets.

Thinking of the ideological implication of all this, it becomes evident that these open systems are actively reconstructing not only notions of participation and expertise, but also the concepts of accountability, transparency, and public deliberation.[30] How far they can go in deferring problems of scale (extension) and in surmounting their narrow project boundaries is—I would argue—a fundamental question for both the social and technical sciences that has only begun to be explored.

Moreover, I believe that at the heart of the ideology of openness lies a new means of addressing the tension between authority, expertise, and social scale. In small communities, expertise can be recognized and affirmed through personal contacts as news and reputation spread quickly in small networks and reputation can be both enduring and 'thickly supported' by multiple interactions. In large communities, in contrast, personal contacts are much less likely to be adequate to this role. Even though the social distance between actors scales much more slowly than the population size—reflecting the 'small world' characteristics of human societies

[30] As Lessig and Gillespie demonstrate, we are steadily slipping towards 'permission culture'. See Gillespie, *Wired Shut: Copyright and the Shape of Digital Culture,* Lessig, *Free Culture : How Big Media Uses Technology and the Law to Lock Down Culture and Control Creativity*.

identified by network theorists—size and complexity has necessitated many forms of signaling of roles and expertise, from diplomas to uniforms. Systems of accreditation exist, in part, to solve the information problem inherent in large social networks: how to provide low-cost signaling of expertise in contexts where personal relationships map only a small portion of the population. The systems discussed here exhibit attempts to bridge this difficulty, scaling up toward large populations while ignoring *a priori* accreditation as a basis for expert legitimation.

Moreover, expertise in open communities is a continuous category, generated through a feedback loop between participation and community recognition. As I showed in Chapter 3 in the cases of Stallman, Torvalds and Tannenbaum, the distinction between expert and layperson is often diffuse or transitory.

As I showed in the case of Linux, under these conditions, expertise is not strictly or solely vested in individuals, and the problem of resorting to a form of 'rough consensus' often solves disputes about authority. My review of many online Linux newsgroup archives, or example, suggests that notion of 'community expertise' plays an important role, although the actors are not always referring to it as such, but, rather, discuss the need for consensus, which is often built around what is perceived to be the 'best' technical solution. Community expertise thus resides in two competing dynamics: (a) the legitimation of 'aggregate' opinion, as opinions tend toward an equilibrium, even on controversial issues; (b) the openness of the community to dissenting opinions, with the potential to change the aggregate consensus. In successful open communities like Linux, these dynamics produce confidence in the knowledge-making process, which extends the confidence in any particular instance of expert opinion, or a particular leader like Torvalds. The system remains legitimate to the degree that it represents a properly constituted authority in the eyes of the community of users. When this legitimacy is eroded, the community risks fragmentation.

Discussion – Open Systems and theoretical models of technological innovation

As I discussed in Chapter 2, the literature recognizes two skeletons upon which the bodies of technological innovation can rest. One is based on private action and independent invention for the sake of profit, the other on centralized funding and top-down approaches. Participatory information networks, like the ones studied here, represent a third model in which the drivers for innovation are not governments or firms but communities of peers who are loosely connected and partake in large-scale collaborative projects where coordination is not governed primarily by market signals and is not organized around managerial structures but, rather, around self-selection of tasks. From an economic standpoint, von Hippel and von Krogh discuss the open model as a middle ground between a "private investment" model where returns to the innovator result from private goods and efficient regimes of intellectual property protection and a "collective action" model that assumes that under conditions of market failure, innovators collaborate in order to produce public goods.[31]

As I was exploring the case studies, I became less interested in the economic aspects and more interested in the social aspects of this middle ground and in its implications for S&TS. I believe that the degree of participation in systems like Linux is an example of a change in quantity that occasions a change in quality. S&TS had always given a lot of attention to the important role that 'users' play in technological systems, and even more so in recent years.[32] So S&TS should be very interested in

[31] See von Hippel and Krogh, "Open Source Software and the 'Private-Collective' Innovation Model: Issues for Organization Science."
[32] See Pinch and Kline, "Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States." See also Nelly Oudshoorn and T. J. Pinch, *How Users Matter :*

communities such as ARRL, GOC, Linux, and BIOS whose members are not simply 'users' but are positioned at the very core of the technological innovation cycle. In these systems members are not measured only along the one-dimensional axis of use/consumption. As I have demonstrated in the case studies, to a large degree systems like ARRL or Linux blur the dichotomies between developers and users, property owners and licensors, managers and workers, innovators and early adopters, consumers and producers. There is a growing body of literature that supports this claim. von Hippel, for example focuses on how users are just as likely as producers to be drivers of innovation even in traditional areas of science and technology; Neff and Stark argue that for both online and offline ICT innovation a common cycle of testing, feedback, and innovation facilitates ongoing negotiations around production and labor organization.[33] My case studies have focused on demonstrating how community-based networks, while often brought to life by a single influential individual or visionary like Maxim, Stallman, or Jefferson, soon outgrow their founders. It is here where the openness of the 'code' changes the process of innovation. As I have shown in Chapter 3, in light of the achievements of systems like Linux, preconceptions concerning the conditions of large-scale technological innovation are called into question. When the code is open, technological innovation becomes less contingent upon the intellectual, financial, or historical constraints present with a specific inventor and instead come to reflect the shared concerns that a specific technology comes to embody over time for

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The Co-Construction of Users and Technologies, *Inside Technology* (Cambridge, Mass. ; London: MIT Press, 2003).

[33] von Hippel focuses on how users are just as likely as producers to be drivers of innovation even in traditional areas of science and technology, see Eric von Hippel, *Democratizing Innovation* (Cambridge, Mass.: MIT Press, 2005), Eric von Hippel, *The Sources of Innovation* (New York: Oxford University Press, 1988). Neff and Stark argue that for both online and offline ICT innovation a common cycle of testing, feedback, and innovation facilitates ongoing negotiations around making products and around organizing production, see G. Neff and D. Stark, "Permanently Beta: Responsive Organization in the Internet Era," in *The Internet and American Life*, ed. P. Howard and S. Jones (Thousand Oaks, CA: Sage Publications, 2003).

specific communities. In cases like this the concept of heterogeneous engineering needs to be expanded. Granted, both Stallman and Jefferson are heterogeneous engineers, and granted, the early adopters of their technologies are users. But staying there gives us only a partial explanation of the dynamics in a system like Linux or BIOS.

While I was trying to find explanations for the four case studies, and to abstract from them a more general framework, I have found it useful to expand SCOT[34] informing it with Lessig's model of regulation.[35] I found that SCOT's traditional focus on artifacts, on relatively small groups of core actors, and specific geographical sites, could be enhanced in order to better explain the transitions from the industrial information economy to the networked information economy. While my main analytic methodology follows SCOT's tradition, I depart from it when I choose to follow Lessig's model of regulation, adding norms, law, code, and markets to the mix of things that are socially negotiated. Lessig argues that norms, law, markets, and code constitute regulatory regimes that influence the behavior and freedoms of individuals and groups within a given society, and that together they set the constraints and limitations on what we can or cannot do.[36] I my analysis, those four categories are the battlegrounds where the fights between the different social groups happen. The systems that I presented in this work are all networks; to this extent, instead of focusing, as many SCOT accounts do, on the artifacts, I followed the different social groups as they debated and negotiated not only the 'code', or the architecture, but also

[34] Bijker, Hughes, and Pinch, *The Social Construction of Technological Systems : New Directions in the Sociology and History of Technology*.
[35] Lessig, *Code and Other Laws of Cyberspace,* Lessig, *Free Culture : How Big Media Uses Technology and the Law to Lock Down Culture and Control Creativity,* Lessig, *The Future of Ideas : The Fate of the Commons in a Connected World*.
[36] Lessig, *Code and Other Laws of Cyberspace,* Lessig, *Free Culture : How Big Media Uses Technology and the Law to Lock Down Culture and Control Creativity,* Lessig, *The Future of Ideas : The Fate of the Commons in a Connected World*.

their norms, markets, and as I showed in multiple instances, the law. I depart from Lessig in my understanding that those four categories are not rigid as his theory might imply. Norms, law, markets, and code, are not stable. They are themselves the results of a social negotiation.

To help and ground the concept of social negotiation around the networks discussed, I introduced the concept of affordances. As I discussed in Chapter 4, *affordance* was a term originally introduced and explored by psychologists. In Chapter 4 and subsequent chapters, I have demonstrated how this definition was too tied to the psychological literature and assumed too essentialist a use of products. I showed how new and unexpected uses of technology by users and participants subjects the very notions of what the technology is good for, or what can be done with it to a process of social construction. This distinction is particularly useful in the analysis of the four categories of regulation. What is available, permissible, possible, desirable, acceptable, etc, within the bounds of norms, law, markets, and code – are all subject to social negotiation among relevant social groups. When these social groups interact they fight one another in an attempt to make one interpretation dominant over the others. Newsgroups alone did not 'afford' the writing of Linux. They allowed a large group of coders to believe that they can get together and share their code in a way that could be sustainable. Likewise, after pressures from the 'market' the law that all but kicked amateurs off the spectrum did not dictate a particular form of social organization around the relay mission, but the perceived affordances of the spectrum below 200 meters—the perception that short wavelengths limited the range of communications—suggested that a relay solution, a solution by 'norms', might be the only way to achieve long distance connections. I had given many other examples to this idea throughout this work, suggesting that while I am not attempting to develop a universal theory for explaining technology in general, I believe that this framework is quite useful for understanding large-scale, multi-sited information networks. If one wanted to understand the collaboratively authored Wikipedia, for example, following this line of inquiry can help focus the explanation and increase its explanatory power.

A related but distinct concern for S&TS is the notion of closure. Is closure—the stabilization of meaning in the eyes of relevant social groups—ever possible in open systems? I think that real closure is never possible for any system let alone in open systems. My recent visit to ARRL headquarters near Hartford, Connecticut offers a vivid example. While there, I had the chance to 'work' W1AW, the Hiram Percy Maxim Memorial Station that is located in Maxim's original shack and is available for visitors for a few hours a day. I was surprised to see other operators engaged in activities that extended much beyond Morse code transmissions or voice communication. One radio receiver in the station was receiving weather data from a NOAA satellite. Another was downloading a high-resolution image of a cat to a connected computer. In both cases the protocol for 'working' the other station were not very different from those of ARRL users nine decades earlier. Some of the equipment too was a few decades old. But the ability to hack around these protocols, to add additional equipment to the setup, such as a personal computer, made it much more interesting, as the station manager told me, to a young generation of hams that grew up with the richness of the Internet, and for whom Morse code messaging might seem dull. Do these forms of re-interpretation depend on the system's openness? Yes and no. Clearly closed systems can be manipulated, reinterpreted, annexed, appropriated, etc. As S&TS had shown, users can always resist pre-conceived meanings and offer their own re-interpretation. What is different here, however, is that there are systematic properties that make it easier. If code, laws, norms, and markets make it easy for participants to appropriate a system to their own needs, they are expected to engage in such activities more often. The plethora of Linux distributions discussed in Chapter 3 is another good example. There is one official version of Microsoft Windows™. There are over a hundred official versions of Linux. To the extent that open systems pride themselves as being open, forever, they may indeed never be closed.

Conclusion and directions for future works -- towards a more democratic culture

So what does all this mean for the future of a democratic society? What does it mean for the idea of democratic culture? While exploring the full implications of open systems for democracy is beyond the scope of this work, in this last section I want to outline a few key ideas around the notion of democratic culture that seem like promising directions for future work.

Balkin defines democratic culture as a culture in which individuals have a fair opportunity to participate in the forms of meaning-making that constitute them as individuals.[37] He discusses the need to give ordinary citizens the means to control the information that determines the meanings of their life. He writes:

> The point of democracy, as its name implies, is to put power in the hands of the people, to give ordinary people some measure of control over the forces that shape their lives and some degree of say about how the world around them develops…Our ideas, our habits, our thoughts, our very selves are produced through constant communication and exchange with others. The influence is reciprocal: Through this continuous communication and exchange, we shape culture and are shaped by it in turn. We absorb it, we inhabit it, we make it new. We send it out into the world, we make it part of us. Culture is more than governance, more than politics, more than law. And if democracy is giving power to the people, then true democracy means allowing people not only to have a say about who represents them in a legislature, or what laws are passed, but also to have a say about the shape and growth of the culture that they live in and that is inevitably part of them. Power to the people—democracy—in its broadest,

[37] Balkin, "Digital Speech and Democratic Culture: A Theory of Freedom of Expression for the Information Society," 42.

> thickest sense, must include our relationship not simply to the state but to culture as a whole, to the processes of meaning-making that constitute us as individuals. Those processes of meaning-making include both the ability to distribute those meanings and the ability to receive them.[38]

Part of my argument throughout this work has been twofold: (1) that the processes of meaning making are growingly technologically mediated, and (2) that to the degree that they are, enhancing democratic culture—enhancing democracy itself—is better served when our norms, our laws, our markets, and our code are open to participation and enhance, rather than limit, access to a knowledge commons. In other words, I believe that democracy is better served when the means of production are distributed more equally, and the relations of production are based on what I might call an 'architecture of participation', by which I mean more than the hierarchical onion model that I presented in Chapter 3. As I discussed at length in each of the case studies, the modes of participation are not simply a matter of social structure. They are the results of a series of social negotiations that involve the reconfiguration of code, norms, markets, and law. Amateur radio's development depended on a legal decision about hams access to the spectrum as much as it depended on a social norm that allows participants to gain social status by enhancing their technical identity. Transbacter's promise to feed hungry people in Africa depends on market outcomes as much as it depends on the complex technical advances in the area of genetic engineering. Linux's inclusion in projects like One Laptop Per Child, which aims to bring a sub-$100 laptop computer to millions of children in developing countries, is the result of a complex process that involves all of the above. But those who believe in democratic culture should not be indifferent to the outcome. Kids growing up with a computer whose operating system can be taken apart, hacked, and reconfigured will be

[38] Ibid.: 36-37.

better citizens, I argue. Or at least better citizens if the alternative is an iPod culture in which the devices used to consume and participate in culture are closed both technically and metaphorically. They will be better citizens exactly because they grow up within the architecture of participation, because they will be empowered—as citizens and as people—to participate in the information economy around them. As Mumford argued, over time democracy itself depends on our ability to enhance technologies that are human-centric, not machine-centric and that empower individuals, allowing them to gain the information and knowledge that are needed to make our life meaningful.[39]

Clearly, openness as an alternative ideology is not necessarily only good news for democracy. As discussed in each of the chapters, openness introduces new moral, ethical, and practical risks. Openness to participation also means that those with the means to participate will be more influential than those without them. The genius of representative democracy is that the masses can, in theory, delegate their political authority to someone else who has the time and education to be politically involved. Under participatory democracy, political power is distributed according to free time, rhetorical resources, education, etc, but not without restraint. Open systems—whether they are consensus-driven communities or meritocracies—may undermine the ability of underrepresented communities to enjoy the protection of state-like power, and therein is their greatest risk. Consensus-based decision-making processes can quickly lead to a lowest common denominator among competing social groups resulting not in innovation but in political paralysis that can lead to social fragmentation or even a deterioration of public goods in the absence of central authority or some form of

[39] For a comprehensive review of the social movement around Access-To-Knowledge and its implication for the law, see Amy Kapczynski, "The Emerging Access to Knowledge Movement and the New Politics of Intellectual Property Law," *yale Law Journal* (forthcoming).

monopoly. Or, to voice critique from a different direction, as discussed in Chapter 6, a reduction in barriers to participation and access to knowledge might result in unintended but hard-to-stop abuse of information and information goods in ways that would threaten privacy and national security (i.e. consider the use of pathogens and encryption technologies by terrorists, or GMOs gone wild). Clearly there might be situations in which society should prefer checks and balances on participation and inclusion by state or state-like powers for the preservation of the common good.

The consequence of these challenges is clear. Openness and open architectures are not some pixie dust to be sprayed on badly designed systems. Nor is openness a panacea to the many complex problems that I discussed such as the GMO debate. Openness must be understood as a specific configuration of social relations. When all is said and done, what ultimately decides what systems can be used for, what technology can do, how, and why, is co-constructed with the meaning we ascribe to it. This meaning in turn is negotiated among social groups and co-constructed while the technology is stabilizing. Clearly, having a better understanding of how open systems work as an ideal-type and in practice, is an essential basis for their stabilization and expansion. Furthering our explanations of the ways in which the ideology of openness departs from or depends upon the ideology of enclosure can help us understand what is at stake. With the basic framework that I developed in this work, I hope that I now have a solid foundation to continue investigating the overall implication that participatory information networks and other types of open systems may hold for democracy.

INTERVIEWS

Name	Date	Location
Paul Ginsparg	09/05/05	Ithaca, New York
Richard Jefferson	10/25/05 07/06/06	Phone Canberra, Australia
Brian Behlendorf	04/01/06	San Francisco, California
Zack Brown	04/02/06	Mountain View, California
Seth Schoen	04/01/06	San Francisco, California
Richard Stallman	05/08/06 06/01/06	New York City New York City
Muroro Dziruni	05/16/06	Chicago, Illinois
Vederan Vucic	06/16/06	Email
Karsten Garlof	06/16/06	Email
Janet Hope	07/05/06	Canberra, Australia
Marie Connett Porceddu	07/09/06	Canberra, Australia
Douglas Ashton	07/10/06	Canberra, Australia
Vivec Rameish	07/10/06	Canberra, Australia
Greg Quian	07/10/06	Canberra, Australia
Robert Blyth	07/10/06	Canberra, Australia
Nicholas Dos Remedios	07/10/06	Canberra, Australia
Carle Boeekene	07/10/06	Canberra, Australia
Perry Williams, ARRL	07/19/06 03/27/06	Phone Newington, Connecticut
Jacob Werksman	08/15/06	New York City
Andrej Killian	08/22/06	Phone
Ronnie Coffman	08/27/06	Phone

Helge Zieler, Chromatic Inc	08/28/06	Phone
Metz Thomas, IRRI	08/28/06	Email
P.S.Bhattacharya, JK Agrigenetics	10/05/06	Email

Additional meetings with academics and experts:

Name	**Date**	**Location**
Eric von Hippel	04/22/06	New Haven, Connecticut
Rishab Ayer Gosh	05/15/06	Chicago, Illinois
Jack Balkin	05/24/06	New Haven, Connecticut
Peter Drahos	07/05/06	Canberra, Australia
Roger Clark	07/06/06	Canberra, Australia

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